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ABSTRACT

An interconnection of computer networks, telecommunications services, and applications, the National Information Infrastructure (NII) can open up new vistas and profoundly change much of American life. This report explores some of the opportunities and obstacles to the use of the NII by people and organizations. The goal is to express how improvements in the technical foundation upon which all modern communications rests can benefit all Americans by focusing on the uses of the NII and the benefits to be derived by applications of advanced computing and communications technologies. This document describes how the evolving NII can: enhance the competitiveness of our manufacturing base; increase speed and efficiency of electronic commerce; improve health care delivery and control costs; promote development and accessibility of quality education and lifelong learning; improve effectiveness of environmental monitoring and assessing human impacts upon the earth; sustain the role of libraries as agents of democratic and equal access to information; and provide government services to the public faster, more responsively, and more efficiently. In addition to articulating a national vision that can serve as a framework for discussion and dialogue, a second goal is to improve public policy-making, to identify critical barriers, enablers, and the tools of government action most effective in each of these areas. In this way, the benefits of government activities in support of the NII can be maximized, while minimizing unintended or undesirable consequences. Several themes emerge: equity of access; pursuit of demonstrations and pilot projects; standards setting process; privacy and communications security; training and support; identification of long-term research and development priorities; and performance measurements to assess both public and private investments and experiments. It is hoped that careful consideration of the policy questions raised here will both facilitate the development of the NII and guide its evolution so that it best meets public purposes. (MAS)

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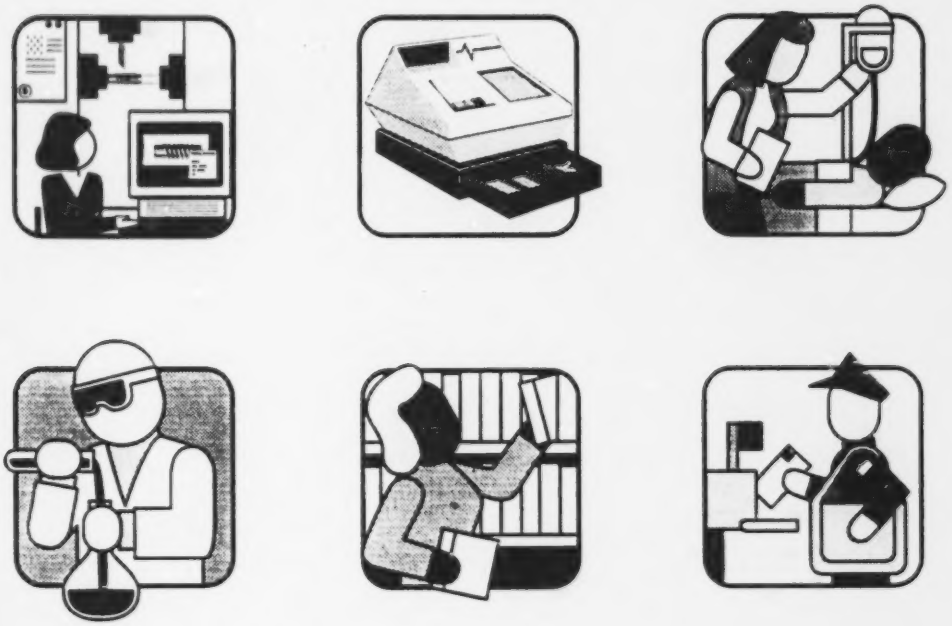
Putting the Information Infrastructure to Work:

Report of the Information Infrastructure Task Force Committee on Applications and Technology



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This paper is intended for public comment and discussion. Your comments can be sent to any of the following addresses:

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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

May 3, 1994

Dear Colleague:

The Clinton Administration has given high priority to working with the private sector to develop an advanced information infrastructure for our country: the National Information Infrastructure (NII). As Chairman of the Interagency Task Force that is helping to shape our vision of the NII, I believe that it is vital for us to continue our dialogue -- private and public sectors -- on the form our future will take.

An interconnection of computer networks, telecommunications services, and applications, the NII can open up new vistas and profoundly change much of American life, not by the fact that it exists but by the way it is used. For that reason, this document explores some of the opportunities and obstacles that are presented when we talk about how people and organizations will use the NII.

This document was prepared by the Committee on Applications and Technology of the Information Infrastructure Task Force. The Committee is charged with coordinating Administration efforts:

- to develop, demonstrate, and promote applications of information technology in manufacturing, electronic commerce, education, health care, government services, libraries, environmental monitoring, and other areas; and

- to develop and recommend technology strategies and policy to accelerate the implementation of the NII.

This document is intended for four important audiences: the general public, the private sector organizations that are building the NII and driving its applications, the committees and working groups of the Information Infrastructure Task Force, and other agencies and departments in our Government.

The topics presented here explore manufacturing, electronic commerce, health care, education, environmental monitoring, libraries, and government services as a stimulus to further debate. This is a limited list, as clearly there are many other relevant applications of the NII.

Sections of the papers are presented as questions. We welcome your input in helping to answer these questions and to raise other relevant issues. Your response will illuminate and guide government policies and investments to accelerate NII applications.

We look forward to hearing from you.

Sincerely,

Ronald H. Brown

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Putting the Information Infrastructure to Work: A Report of the Information Infrastructure Task Force Committee on Applications and Technology

Office of the Director
National Institute of Standards and Technology
Gaithersburg, MD 20899–0001

May 1994

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Introduction

DRAFT FOR PUBLIC COMMENT

"I know of but one single means of increasing the prosperity of a people that is infallible in practice that I believe one can count on in all countries as in all spots. This means is naught else but to increase the ease of communication between men . . . America, which is the country enjoying the greatest sum of prosperity ever accorded a nation, is also the country which, proportional to its age and means, has made the greatest efforts to procure the easy communication I have spoken of. Of all the countries of the world America is the one where the movement of thought and human industry is the most continuous and swift."

– Alexis de Tocqueville, 1835

PART I: Introduction

The goal of this document is to express how improvements in the technical foundation upon which modern communications rests can benefit all Americans. We call this platform the National Information Infrastructure (NII), meaning the facilities and services that enable efficient creation and diffusion of useful information. We wish to focus the public debate on the uses of the NII and the benefits to be derived by applications of advanced computing and communications technologies. This collection of papers describes a national vision for how the evolving NII can:

- enhance the competitiveness of our **manufacturing** base
- increase the speed and efficiency of **electronic commerce**, or business-to-business communication, to promote economic growth
- improve **health care** delivery and control costs
- promote the development and accessibility of quality **educational and lifelong learning** for all Americans
- make us more effective at **environmental monitoring** and assessing our impacts upon the earth
- sustain the role of **libraries** as agents of democratic and equal access to information
- provide **government services** to the public faster, more responsively, and more efficiently

In addition to articulating a national vision that can serve as a framework for discussion and dialogue, a second goal of this collection of papers is to improve public policy-making, to identify critical barriers, enablers, and the tools of government action most effective in each of these areas. In this way we can maximize the benefits of government activities in support of the development of the NII while we minimize unintended or undesirable consequences.

While the term NII is new, the promotion of innovation in communication and transportation is among the proudest elements of our American heritage. From the postal roads, canals, and railroads to the telegraph, telephone, interstate highways, and the spacecraft with which we loft our satellites skyward, America has been fearless in its pursuit of new and better ways of moving people and their ideas. And nearly every generation has sought ways to pursue public purposes by properly guiding these innovations.

Moreover, the facilitation of free and open communication is the centerpiece of American law and culture. Freedom of speech and expression, protection of an inviolate private realm, and institutions by which the popular will may be expressed are the fundamental principles upon which our nation was founded. The task before us is not just to defend these ideals as historic artifacts, but to deepen, enliven, and enrich them; to give them new life in our time and a foundation that will maintain them in the new century that lies before us, as ever more capable tools for human communication evolve and are adopted.

Yet, while the American people acting collectively through their government have established and enforced guiding principles, it has been the American people acting through private industry who have built and maintained most of the core elements of the infrastructure in previous generations. This will not change. The very dynamism that forces us to address questions of industrial convergence—technological innovation in fields ranging from electronics to entertainment—stems in large measure from our past commitment to seeing the business of communications remain in the hands of private citizens.

The government's role is to set the rules for competition and enforce them, ensure that improvements in public communication benefit all Americans rather than a select few, promote the adoption of standards that allows systems to interoperate, ensure that intellectual property rights are respected, support research to improve information systems and make them easier to use, be a wise purchaser of information technologies and services, and reduce uncertainty and risk by funding pilot projects that demonstrate the usefulness and economic efficiency of new services and applications.

This introduction will identify some of the themes common to all of the papers in this first collection. Before doing that, however, a few other introductory notes are important concerning the scope of these papers and the process for ensuring widespread circulation and comment.

These papers are the first set the Committee on Applications and Technology has chosen for development. We identified these as the core set because there are significant public interests to be served by the application of advanced information and communication technologies in these arenas and some key government activity already underway. The next collection of papers could include such things as entertainment, arts and culture, demand-side management of electrical power, the NII and Americans with disabilities, information technologies in the workplace, political participation and community networking, transportation, telecommuting and other topics. We look forward to getting the next set of papers underway and welcome input on topics of greatest interest.

This collection of papers represents the most detailed effort to date of the Information Infrastructure Task Force (IITF) to articulate the opportunities presented by an advanced NII and identify some of the obstacles to its deployment. To invite as much public comment and debate as possible, the potential actions identified below and in the papers themselves are stated as questions on which we are seeking your views. We are trying to move the national debate forward so that our discussions as well as our actions are considered judicious, and well-informed.

PART II: Issues Common to all of the Applications Papers

Several themes emerge as concerns common to all of the papers. They are equity of access, the pursuit of demonstrations and pilot projects, the standards setting process, privacy and communications security, training and support, identification of long-term research and development priorities, and performance measurements to assess both public and private investments and experiments.

Equity of Access: Improved means of information access and dissemination must serve to close the gap between those with more influence and those with less; it must lower the obstacles to full and complete citizenship in American society rather than raising them.

Earlier this year, the President and Vice President set a goal of connecting all hospitals, clinics, libraries, and classrooms to the NII by the end of the century. Doing so will empower citizens and help reinvigorate their public institutions. Hearings are being held to assess strategies for achieving universal telephone service. While the Administration is funding demonstration projects through the National Telecommunications and Information Administration (NTIA), this will only connect a small number of public institutions to the NII. The Administration's proposals for telecommunications reform will ensure low cost basic telephone service and maintain the ability of communities to require cable operators to connect public institutions at little or no charge. To ensure that public institutions can continue to serve their historic functions this must be preserved in the new regulatory regime. To this end, should the Federal Communications Commission propose regulations that enhance the availability of advanced telecommunications services to all educational and health care institutions and libraries by mechanisms such as preferential rates for telecommunications services? Are there alternate means for achieving this public requirement?

Demonstrations and Pilot Projects: Among the key obstacles to the adoption of new communications techniques is risk and uncertainty as to the benefits. In the adoption of health information systems, for example, uncertainty among private sector purchasers of these systems about their ability to exchange information accurately must be overcome before the costs and benefits of such systems may be proven in clinical practice. In the case of libraries, mechanisms to ensure that works placed in the system will be protected from unauthorized uses will be required if copyright owners will make their works available under appropriate terms and conditions. Teachers and administrators must be able to see that networked-based teaching tools improve the educational process before deciding upon widespread adoption of these techniques. How can interactivity as a technical attribute of advanced networks best be incorporated into services that facilitate genuine social and political interaction among citizens and consumers, and between them and the companies and governments that serve them? The federal government is currently supporting a host of demonstration projects, as described in this collection of papers. What future NII applications can be demonstrated in ways that will allow later scaling to community- or society-wide status? How can these simulations be conducted under conditions that closely resemble what would be found if they were fully operational?

Standards: Standards for information content, display, and exchange are such a crucial element in the development of the NII that it may be said there is no infrastructure without them. In addition, there is a significant international component to the adoption of standards. The United States can no longer assume that other nations will adopt our standards or purchase products built to U.S. developed standards. Standards may be effective barriers for product entry in foreign markets.

There is an urgent need to make the selection of standards for information technologies and services as efficient as it can be. Broadly speaking, the government's role is to set clear goals and be an intelligent adopter of standards, and to ensure the best possible coordination among standards organizations, industry, and the government so that the private, voluntary standards system in use in the United States works to maximum efficiency. How can the adoption of standards best be improved? In addition, what specific standards-setting activities and decisions are of greatest importance to the development of the NII? How may the government facilitate consensus among relevant parties? Is it possible to identify interfaces between technologies and services where the establishment of common standards would enable faster infrastructure development and those interfaces that inhibit infrastructural improvements because they are not open?

Privacy and Communications Security: Among the most notable shortcomings of today's Internet is the inability to be sure of the identity of someone with whom one is exchanging electronic mail, and uncertainty as to whether a message was read by unintended parties. If com-

munications over the NII are not secure, then people will not honestly report their condition to their physicians. If physicians do not trust the NII to maintain confidentiality they may misreport sensitive medical information to insurance companies. Both of these not only degrade the efficiency of the health care system but will undercut the ability of advanced communications to make people healthier. Electronic Commerce also shows the same requirements. Few business class applications will develop on the NII until an infrastructure is in place to guarantee a high level of authentication and privacy.

The IITF's Privacy Working Group has been working on a Code of Fair Information Practices that is soon to be issued. This report will address issues related to the privacy of electronic records. The National Institute of Standards and Technology has been working on strategies for implementing a national infrastructure for the management of public key cryptographic techniques for authentication and confidentiality. It will address such questions as: How should it identify a registration service that would issue policies and certificates? What is the best way to identify the work remaining to be done in protocol development for the interchange of certificates? How should it identify the necessary and sufficient services of the infrastructure itself to support Electronic Commerce and determine the initial entities to start developing actual services, such as government agencies and commercial service providers? Should these questions be addressed by a conference, a panel of experts, or some other process?

Training and Support: Professional development and technical assistance often lag well behind the adoption of advanced communications tools. This has been identified as one of the most important obstacles to the development of NII applications in the areas of education and lifelong learning, libraries, and health care. Even the most cleverly designed and implemented advanced communication techniques will not be used if teachers and administrators, health care providers, and librarians do not understand how to use them. Improving the ability of these professionals to interact with the people they serve depends upon their being trained and practiced to use the new communications techniques that are at their disposal. Failure to adequately train these professionals will obviate any improvements in services delivered over the NII. How can we ensure the training that professionals receive keeps pace with advances in the capabilities of the NII?

Research and Development: One of the most effective tools for the promotion of the NII is the investment the federal government makes in research. Many of the current search and retrieval tools on the Internet today were created with the help of government-sponsored research. Government research today in such areas as advanced manufacturing techniques, digital libraries, and environmental assessment tools will be the foundation for future capabilities and commercial products. The newly formed National Science and Technology Council is charged with advising the President on how the federal research investment may be best managed. Under its purview, the High Performance Computing and Communications program coordinates key NII technology efforts across the government. How can federal research best support the key technical underpinnings of the NII, ranging from product data standards to digital storage, retrieval, and dissemination technologies?

Performance Measurements: Demonstrations, pilot projects, and research expenditures are never ends in themselves. Without a set of metrics, it is impossible to tell if either public or private experiments with new services or cooperative research efforts have been successful. Monitoring and understanding the results of programs and experiments is therefore crucial for future decision making. How can we develop program evaluation techniques that help people understand the effects and results of experimentation with the tools of an advanced NII? How can the costs and benefits be best assessed and the understanding be widely shared, so that many people benefit from government expenditures, whether they take the form of the funding of pilot projects or cooperative research and development efforts? How do agencies ascertain whether these investments are yielding their anticipated national benefits? In short, how can we be sure to learn the right lessons?

PART III: Conclusions

As we begin to identify and understand the potential benefits of an advanced NII and develop policies to accelerate its development, we must tightly couple federal initiatives and programs to the goals, priorities, and activities of

industry, academia, and labor. Only by effectively linking the complementary activities of the public and private sectors can we accomplish technological, economic, and social objectives that will pay dividends to the entire nation.

There is no ineluctable force pulling these advanced applications of the NII into being. Nor can the simple statement of desirable future characteristics of the NII make it so. Success in each application arena requires the identification of intermediate goals and objectives and the successful negotiation of outcomes involving a multitude of different parties. Only conscious, willful, and well informed public decisions will result in an NII that meets America's needs.

We hope that careful consideration of the policy questions in these papers will both facilitate the development of the National Information Infrastructure and guide its evolution so that it best meets public purposes. The most important performance measurements for the NII are not technical but social. The NII should—and will—be judged not by the speed at which bits may race to their destination to be reassembled into words or images, but by how well these technical capabilities make the nation and its citizens healthier, wealthier, and more wise.

Manufacturing and the NII

DRAFT FOR PUBLIC COMMENT

PART I: What Is the Application Arena?

Description of Manufacturing[1]

From automobile and computer products to wood furniture, U.S. manufacturers face intense competition that threatens their very survival. Indeed, today's competitive advantage knows no national boundaries, going only to those manufacturers who can rapidly respond to ever-changing market demands with high quality, customized, competitively priced goods. U.S. manufacturers and workers have the skills, desire, and potential to succeed, but their success is by no means certain.

In the new manufacturing paradigm, the efficient and effective management, manipulation, and use of information is essential to sustained economic vitality and growth. With information as a strategic asset, the integration of information technologies—in an infrastructure of communications networks, hardware and software applications, databases, bulletin boards, and other services glued together through common interoperability and data exchange standards—holds one critical key to manufacturing success. An advanced National Information Infrastructure (NII) will enable both the modernization and upgrading of traditional design, development, production, and support processes as well as the complete re-engineering, optimization, and integration of separate business functions, activities, and enterprises.

NII applications in manufacturing have the potential to transform and significantly improve all stages of manufacturing operations, from technology/market assessment and R&D to aftersales support and product disposal or reuse. Effectively applied information technology has a greater potential to change the way manufacturers do their work than the steam engine had in the Industrial Revolution. While the gains in productivity, quality, flexibility, and cost will be large, the greatest benefits will be realized through the combination of technology with organizational and managerial changes, enabling entirely new ways of working—as well as the creation of entirely new industries.

The potential benefits of an advanced NII to manufacturers come from the gains in a number of areas. The ability to quickly and efficiently transfer data within and among operations can revolutionize the design process, enabling concurrent collaboration and communication among suppliers, partners, customers, and competitors at distributed locations. It can enable the rapid vertical and horizontal integration of companies; accelerate first time optimization of products from design to production; reduce the number of design changes; enable "virtual" modeling, simulation, and testing; reduce waste and increase yields—with greater quality and increased flexibility and responsiveness.

[1] For the purposes of this paper, "manufacturing" refers to the discrete parts manufacturing industry, although the trends, issues, and opportunities discussed in this paper can be applied to a great extent to other industries.

Imagine a future where:

- Customers "custom design" products such as automobiles and clothing, electronically transmitting their requirements to remote locations capable of quickly manufacturing and distributing these products.
- Companies rapidly and easily form alliances needed to produce new products, employing advanced manufacturing concepts such as "agile" and "virtual" manufacturing.
- Small- and medium-sized companies advertise their manufacturing capabilities over computer networks and efficiently bid on projects required by other companies.
- "Software system brokers" connect users who have a need for temporary access to sophisticated manufacturing tools that would normally be too expensive to acquire.
- Manufacturers and suppliers use "intelligent" procurement systems to facilitate and speed parts procurement, billing, and payment transactions, reducing costs, improving accuracy, and meeting customer demands in a timely manner.

An advanced NII can make available the best manufacturing application tools, knowledge bases, product information, and training materials regardless of location. Using advanced databases, bulletin boards and other services available on the NII, manufacturers can rapidly disseminate requirements and specifications for parts and subassemblies, letting the most qualified and competitive suppliers respond without prejudice to location or size. Over computer links and networks, companies can quickly adopt innovations in materials, parts, and manufacturing processes, advising suppliers of new capabilities at reduced costs. With an advanced NII, companies can quickly integrate data from distributed resources and use this data to create, model, test, and evaluate products, processes, and enterprises in real time and under a wide variety of simulated conditions, guaranteeing first time optimization while satisfying unique customer preferences and manufacturing requirements.

With the continued development of other advanced manufacturing technologies such as intelligent machines and processes, engineering design and planning systems, and intelligent sensors and controls, U.S. companies can fully implement advanced manufacturing techniques such as concurrent engineering and agile manufacturing. By integrating advanced manufacturing technologies with an advanced NII, companies can identify, record, and manage a product throughout its life cycle, enhancing the quality, flexibility, and responsiveness of their manufacturing operations, while generating rapid production and product improvements and reducing unusable inventories, waste, rework, and costs.

An advanced NII can also create entirely new business opportunities in such areas as services for processing, analyzing, and disseminating manufacturing information. It can create new opportunities for consulting services to assist companies in identifying opportunities to improve or reengineer their business processes and to develop strategic plans for migrating from their existing infrastructure to advanced manufacturing and other information technology applications.

Finally, and most dramatically, in combination with other NII applications arenas such as electronic commerce, digital libraries, and education, an advanced NII in manufacturing can greatly affect the overall cost and efficacy of an entire business operation, including financial transactions, market analysis, workforce education and training, and supplier/customer relations. By linking businesses via electronic commerce and banking services, financial settlements can be made in real time with minimal paper work, thereby reducing outstanding balances and financial risks for small businesses. Through real-time networks with suppliers and customers, companies can identify trends, respond to problems, survey needs, and quickly prepare for and swiftly react to everchanging market demands. Finally, advanced education and training available via the NII can help workers develop new skills and remain prepared, flexible, and comfortable with information technologies in the face of continuous and rapid technological change.

What Is the Public Interest in Promoting the Application?

The national impact of a highly advanced manufacturing infrastructure can be enormous in terms of international competitiveness, economic

growth, and standard of living. Manufacturing accounts for nearly 20 percent of gross domestic product (GDP) and represents approximately 17 percent of all U.S. employment. It is the foundation of a diversified, interdependent, vibrant economy, providing a large share of the industry funded R&D and purchasing heavily from the service sector to support its operations. In addition, the service sector, which represents more than 70 percent of the U.S. economy, is increasingly dependent on high quality, low cost, customized goods supplied in a timely manner, and relies on manufacturers for the products it sells as well as the hardware, software, and other technologies it uses to market, support, track, and evaluate its inventories and sales.

In the face of shortening technology and product life cycles and increasing technological complexity, the ability to manufacture high quality, competitively priced goods such as microelectronic components, automobile and aircraft parts, and telecommunications devices in the United States is critical to the nation's overall economic competitiveness. As a result, in addition to their own economic value, manufactured products contribute to and often drive technological innovations in downstream products and services, and therefore much of the value added in the economy. The ability to integrate highly sophisticated, nextgeneration components into downstream products and services requires close working relationships among component and end product manufacturers and service suppliers. Historically this synergy has been difficult to achieve between U.S. companies and foreign suppliers.

In addition, as information and information exchange become more valuable to economic performance, those countries that develop an effective advanced information infrastructure will gain competitive advantage in global markets. Instead of just chasing low wages, as has been the trend in the recent past, manufacturers increasingly will choose to locate and invest in countries whose infrastructure is able to handle the rapid and efficient control and dissemination of information and the integration of diverse business operations. Consequently, an effective advanced NII in the United States can make the United States the country of choice for manufacturing and manufacturing R&D, with enormous and lasting positive impact on the national economy.

Evidence of the Benefits

Numerous studies and implementations of advanced manufacturing applications supported by an improved information infrastructure demonstrate the impact the NII can have on manufacturing products and processes. It should be noted that while automation and networking of existing manufacturing processes will bring significant benefits to many U.S. manufacturers, the ability to manufacture differently, that is to integrate traditionally separate manufacturing processes in combination with new management and business practices, will bring the lion's share of benefits.

Specific Examples

Edward Deming and other quality champions have found that the process of design exerts the most influence over a product's life cycle. For example, approximately 60 percent of a product's cost is fixed early in the process of design and, overall, the design process may fix as much as 90 percent of the total cost of a product. The application of information technologies such as computer-aided design and concurrent engineering techniques, however, can reduce product defects by as much as 80 percent. Other studies support these results. For example, one study found that advanced manufacturing techniques that enable the rapid exchange of information not only increase quality and cut the number of design changes by 50 percent, but also reduce total costs by 30 to 60 percent, development time by 35 to 60 percent, design and product defects by 30 to 80 percent, and scrap work by 58 to 75 percent. An advanced NII will enable manufacturers to take full advantage of the productivity improvement potential of computer-aided design and other information technology and advanced manufacturing technologies [Carver, pp. 14,20].[2]

Combining significant investments in advanced manufacturing equipment and techniques with intensive education and training programs for its workers, John Deere & Co. has been able to reduce production costs and design time while

[2] For more details, see Winner, Robert, "Information Infrastructures for Integrated Enterprises," Institute for Defense Analyses, Volume I, 1991.

improving product quality and productivity. "[Acting] as a blueprint for the revival of other manufacturers," Deere has introduced advanced manufacturing methods such as just-in-time inventory control, teamwork, and supplier integration with the results of reducing inventory by 20 percent, cutting design time by 33 percent, and speeding delivery time to twice a week from twice a month. Deere's investments in both technology and workers have led to a dramatic resurgence in its competitive position. Profits that rebounded in 1993 are expected to increase by an additional 35 percent in 1994 [Kelly, p. 65].

Thanks to computer-based concurrent engineering and improved communication among design teams which enabled simulation, consistency, and the sharing of data among concurrent work teams, Intel Corp. has been able to reduce the time from design-to-sample in half, even though product complexity doubled. In addition, the company achieved a 95 percent success rate on the first silicon fabrication of new products. As a result of those successes, Intel Corporation, in the face of a dozen Japanese competitors, has retained 95 percent of the flash memory market [Davidow, p. 94].

Faced with heavy competition from Asia that had driven out all other U.S. pager manufacturers, Motorola implemented a concurrent engineering system, completely revising its production strategy. Using soft automation, flexible computer controlled machines, a new modular conveyor system, and a computer-based order entry system, less than 18 months from the program's start order times were reduced from one month to minutes; manufacturing time, from 5 hours to 3 [Manufacturing A La Carte, p. 29-32].

In the Japanese automobile industry, implementation of proprietary concurrent engineering systems enabled Japanese auto makers to decrease time-to-market for new cars by more than 30 percent, helping them to gain considerable market share and to increase pressure on U.S. auto makers [Carver, p. 20].

A study of the impact of a common data management, storage, retrieval and exchange service for transferring in a standard digital format all contractor design and manufacturing data among the Air Force and its B2 subcontractors found significant savings. This study, *CALS Contractor Integrated Technical Information Service (CITIS): Business Case Feasibility Study*, determined that the CITIS would lead to a 50 percent reduction in the number of attendees at meetings between contractors and the Air Force, a 5.4 percent reduction in the total B2 spares dollars, a 23 percent reduction in modification lead time, a 1.8 percent increase in the average availability of aircraft fleet, and a 90 percent reduction in the contractor data submittals. The total estimated cost savings ranged from a minimum of $536 million to a maximum of $894 million, for investments that ranged from $9 million to $30 million.

Through the use of just-in-time inventory control and total quality management practices, Harley Davidson reduced manufacturing cycle time for motorcycle frames from 72 days to just 2, while increasing final product quality from 50 percent to 99 percent; Digital Equipment Corporation reduced overall inventory from 16 weeks to 3, while reducing its defect rate from 17 percent to 3 percent; and 3M attained a 70 fold reduction in critical defects, appearance defects, and packaging problems [Davidow, p. 94, (from O'Neil and Bertrand, Developing a Winning JIT Marketing Strategy, 1991)].

Through its use of the ODETTE (Organization of Data Exchange via TeleTransmission in Europe), an electronic communications network, the French automobile manufacturer PSA Peugeot Citron was able to create closer, more efficient ties with its many suppliers and implement "just-in-time," "quick response" inventory control. As a result, Peugeot, "was able to reduce inventories and operating costs, while increasing the quality of its products and customer satisfaction levels. The company went from a monthly order cycle to a multi-day one. It improved inventory turnover by nearly 40 percent, cut the number of nonassembleable cars on the line by 70 percent, and offers customers nearly 30 percent more models to choose from [Teresko, p.36]."

PART II: Where Are We Now?

Background

The information infrastructure has always been a fundamental part of manufacturing in the United States and many companies and government agencies

have excelled at information exchange, control, manipulation, and use. As seen above, there are numerous success stories which highlight the fact that U.S. manufacturers have been and remain at the vanguard of the design and implementation of leading edge advanced manufacturing technologies. In addition, U.S. companies maintain strategic advantages relative to their foreign counterparts in a number of key information technologies, including hardware and software and telecommunications equipment.

While many U.S. companies are leading the world in R&D and deployment of advanced manufacturing technologies, the overall use of information technologies by manufacturers in the United States, especially small- and medium-sized manufacturers, remains low (see tables below). With some notable exceptions, most U.S. companies are organized to take advantage of stable, mass production markets and have specialized tasks, seeking to minimize expenses, divide and separate work. To increase the speed of design and production and reduce costs, they have developed and implemented automated technologies, such as computer-aided-design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), and computer-integrated manufacturing (CIM). Their successes in the past have led to the further fragmentation and division of labor and activities and the creation of narrow, focused activities within rigid, hierarchical bureaucracies.

The result of these trends is that, for the most part, where information technologies have been developed and applied to manufacturing operations, it has been done with a high degree of sophistication yet with a narrow focus that makes integration of these manufacturing technologies not economically feasible. As a result, while U.S. manufacturers excel in product R&D and innovation and the automation of individual components of the overall manufacturing process, they frequently fare less well in the combination of individual technologies into an integrated manufacturing system, embodying such concepts as concurrent engineering, total quality management, and just-in-time inventory control.

Moreover, most U.S. manufacturers have traditionally invested less, and subsequently use less and performed more poorly in commercial product improvement and process improvement relative to their foreign counterparts. For example:

> In the 1970s and 1980s, fixed capital investment in manufacturing (as a share of manufacturing output) was 1.5 times higher in Japan than in the United States. In developing new products and processes, Japanese firms allocate to tooling and equipment almost double the share of total project costs as the amount spent by American companies. . . . Over three-fifths of U.S. machine tools are 10 or more years old, while more than one-quarter are 20 or more years old. . . . Proportionately, Japan now uses numerically controlled (NC) machine tools at 1.5 times the rate in the United States 27 per thousand manufacturing workers compared with 18 per thousand in the U.S. [Shapira, p. 3].

Adoption and diffusion rates of technology are also a problem in the United States. A recent study by the National Institute of Standards and Technology reports that it takes 55 years for 90 percent of United States manufacturers to adopt a technology, compared with 18 years in Japan [Manufacturing Extension Partnership, p. 10]. In addition, while the use of information technologies for inventory control and tracking are reaching saturation in retail applications, they are far less prevalent in the industrial sector, where, for example, only some 30 percent of products are barcoded [Stevens, p.17]. As seen below, investment, adoption, and diffusion rates are most acute for small- and medium-sized manufacturers, whose rates trail those of larger companies, and dramatically lag foreign competition (see tables below).

Table 1. Percent of U.S. Establishments Using Selected New Manufacturing Technologies in 1988 by Size of Establishment (employees)

Technology	20-99	100-499	500 +
Design and Engineering Automation Technology (CAD/CAE)	29.8 percent	54.4 percent	82.6 percent
Flexible Manufacturing Cells or systems	6.5	16.2	35.9
Numerically Controlled/Computer Numerical Controlled machine tools	35.9	50.0	69.8
Local Area Network for technical data	13.1	25.9	58.6
Local Area Network for factory use	11.0	22.9	50.7
Intercompany computer network linking plant to subcontractors, suppliers, or customers	9.7	22.7	41.8
Programmable Controllers	22.5	48.1	77.8
Computers used for control on the factory floor	18.9	41.0	68.0

Source: Shapira, p. 13.

Table 2. Japan-U.S. Ratio of Advanced Manufacturing Used By Small- and Medium-Sized Enterprises (fewer than 500 employees) and Large Manufacturers (over 500 employees)

Advanced Manufacturing Technique	SME	Large
NC/CNC Machine Tools	1.4	1.1
Flexible Manufacturing Cells	4.3	1.9
ComputerAided Design	1.1	0.9
Automated Inspection	2.9	1.5
Handling Robots	4.1	1.4
Automatic Warehouse Equipment	5.8	1.8
Assembly Robots	2.1	1.2

Source: CTI study, based on data from the Industrial Technology Institute.

Low investment, adoption, and diffusion rates are a concern since it is only through the use of a technology that familiarity with its capabilities occur. Low investment and low diffusion rates mean that businesses which are initially uncomfortable with new technologies remain skeptical of the ability of advanced manufacturing strategies to affect competitiveness. In addition, firms that under-invest in new manufacturing equipment lag not only in their comfort and understanding of information technologies, but consequently in the use of combinations of technologies for modern manufacturing techniques such as continuous flow processing, just-in-time inventory control, and concurrent engineering. This under-investment puts U.S. manufacturers at a competitive disadvantage in world markets.

Private Sector Activities

Today, the increased pressure to reduce innovation time, the growing technical complexity of products and processes, and the need to be more responsive to external demand for quality, customization, and cost are rapidly shifting the manufacturing paradigm from one that rewards low cost, mass production manufacturing systems to one that rewards small production run, flexible manufacturing systems. This situation is true for small and large firms alike. As a result, companies are seeking ways to break down the walls that have traditionally separated operations within a company as well as the barriers that have inhibited communication with customers, suppliers, partners, and even competitors.

To remain competitive, many companies, in particular large companies, are investing heavily in automated manufacturing equipment, process technologies, and networking capabilities. For example, the Boeing Company has invested $5 billion in creating a paperless design and manufacturing infrastructure for its next generation "777" aircraft. Other manufacturers, such as General Motors, Ford, Newport News Shipbuilding, Caterpillar, and Intel have instituted programs to develop or purchase new equipment and technology and integrate them with existing capabilities in order to create a seamless, flexible manufacturing environment.

Yet, despite the achievements of these and other of America's premier manufacturers, without the development of an advanced NII capable of transmitting data quickly and efficiently from one application to another inside and outside their operations, most businesses will remain isolated and incapable of integrating their applications interacting with other companies, suppliers, and customers in a timely and cost-effective manner.

In an attempt to remedy this situation, U.S. companies and government agencies are beginning to develop, demonstrate, and promote NII-related manufacturing applications and services. These activities take the form of industrial extension services, enterprise integration and electronic commerce applications, and R&D consortia. They include the following:

The Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP), sponsored by the National Institute of Standards and Technology (NIST), is an industrial extension service designed to help U.S. manufacturers modernize manufacturing equipment, redesign processes, and improve relations with suppliers and original equipment manufacturers. The MEP achieves this through regionally based extension centers which provide technical assistance with new management and organizational practices, shop floor design and manufacturing process evaluation, workforce education and training programs, and deployment of appropriate advanced manufacturing technologies and manufacturing best practices. A key component of the MEP is its information infrastructure program, known as LINKS, which electronically connects the MEP's Manufacturing Extension Centers to a vast array of technology resources available throughout the nation (e.g., national labs, private services, universities).

The LINKS pilot program, Technologies for Effective Cooperation Network (TECNet), effectively demonstrated the potential value of linkages among the Extension Centers. The next stage is to add services requested by clients and centers and to implement a user friendly front-end allowing transparent access to data repositories resident on the major network systems (e.g., World Wide Web, Gopher, WAIS, etc.). Databases of best practices, firm demographics, and corporate information will be added to the system along with access to manufacturing analysis and workforce assessment tools. Eventually video teleconferencing, on-line training, and the capability to perform electronic commerce with business and product data will be added.

Most of these applications will be initially developed, implemented, expanded, and extended through the following projects sponsored by the Technology Reinvestment Project and deployed by the MEP:

The Manufacturing Extension Partnership's Technology Network (MEPnet) is an electronic network and communication system intended to expand and enhance the TECNet pilot. It will start by linking the NIST Manufacturing Technology Centers (MTC) and Manufacturing Outreach Centers (MOC) to each other, providing access to federal technology resources and the ability to communicate directly with clients. Eventually it will provide a forum for direct communications among small- and medium-sized manufacturers. Employing the capabilities of the Microelectronics and Computer Technology Corporation (MCC) Enterprise Integration Network (Elnet), MEPnet will provide a set of online services, including directories, design and analysis tools, databases, and search mechanisms for the secure, easy, and timely exchange of manufacturing information in such areas as process analysis, benchmarking, quality assessment, and best practices. This scalable prototype will connect MTCs, MOCs, 2 National Laboratories,

3 Department of Defense Centers, and can be extended to a potential user base of 370,000 small- and medium-sized manufacturers.

Manufacturers' EnterCorp (MEC) will provide a practical, comprehensive, integrated, electronically linked service for manufacturers to quickly pinpoint specific needs and match them with the best network resources to fill them. MEC is a consortium of midwestern manufacturers that, in cooperation with Sprint, will use an enhanced version of Elnet to enable smaller companies to share resources in the areas of product realization, design, prototyping, analysis and testing, production, and training. The initial market for MEC services is the 5,000 small- and medium-sized manufacturers in Missouri, Kansas, and Colorado. Partners in the organization include Allied Signal; Colorado State University; Day and Zimmermann, Inc.; DeMaTec Foundation, Inc.; Kansas Manufacturers Association; Kansas State University; MidAmerica Manufacturing Technology Center; Kansas Technology Enterprise Corp.; Metropolitan Community Colleges; Pittsburg State University; Sprint; and the University of Missouri.

TEXAS-ONE, created by the Texas Department of Commerce, is intended to help small Texas manufacturers become comfortable with electronic commerce by providing an electronic network that is easy to access, affordable, and contains applications that are targeted at the small manufacturer's needs. Core participants include the Texas Department of Commerce; the Texas Department of Information Resources; the Texas Innovation Network System; Texas Marketplace; the Institute for Manufacturing and Materials Management at the University of Texas, El Paso; and the Microelectronics and Computer Technology Corporation (MCC). Initial applications include Borderbase, and on-line information systems providing demographic, socioeconomic, market, and customs data in support of U.S./Mexico commerce; Texas Market Place, a statewide electronic bulletin board service to promote buyer/seller exchanges; and the Texas Assessment Center, which provides information on hardware and software products as well as access to State information resources.

CommerceNet is an open, Internet-based infrastructure to support the exchange of electronic data conceived of and operated by a consortium of Silicon Valley's major electronics manufacturers, software developers, and information service providers. Created under the auspices of Smart Valley, Inc.—a consortium which includes Hewlett Packard, Intel, Sun Microsystems, Apple, National Semiconductor, and Texas Instruments—CommerceNet will enable companies to revolutionize the way they design, manufacture, sell, and support their products by making interactions with customers, suppliers, and partners efficient, high quality, flexible, and responsive. Demonstration of the power and effectiveness of CommerceNet will attract hundreds and eventually thousands of small- and medium-sized companies, creating an integrated marketplace for the design, production, sales, and support of semiconductors, electronics, computers, and software capable of meeting the demands of 21st century manufacturing.

National Industrial Information Infrastructure Protocols

The National Industrial Information Infrastructure Protocols (NIIIP) Consortium, led by IBM and including participants from the software industry, private and public research organizations, universities, and defense and commercial products companies, is developing a series of computerbased protocols to enable the widespread deployment and use of virtual enterprises within America's industrial community. Sponsored in part by the Technology Reinvestment Project (TRP), the NIIIP will provide the software architecture, tools, and mechanisms to allow diverse organizations to work together as a virtual enterprise toward common goals by means of computer technology. The NIIIP will demonstrate several Challenge Problems through pilot projects which show the value of concurrent product and process design, project control, and distributed manufacturing. The NIIIP will consolidate, rationalize, and integrate a set of standards upon which applications will be built and virtual enterprises will be formed. The approach is to converge commercial off-the-shelf standards and

tools, take advantage of the skills and experience of Consortium members (the leading practitioners of each of the relevant technologies), and develop an easily-accessible and secure "plug and play" environment that embraces both new and legacy applications and offers a powerful solution for the virtual enterprise.

Rapid Response Manufacturing

Four large U.S. manufacturers – General Motors Corporation, Ford Motor Company, Texas Instruments, and United Technologies – have joined forces with the U.S. Departments of Commerce and Energy to create a consortium to improve the process of rapid response manufacturing (RRM). The ultimate goal of the consortium is to reduce the time it takes an enterprise to design and manufacture products and get them to market. The RRM Consortium intends to enhance and adopt key technologies to enable the use of advanced, highly integrated systems for manufacturing. RRM consortium participants work to create computer-based tools to better assure an accurate first part, achieve one-pass product designs by developing intelligent software systems to analyze and choose optimum designs, and provide simultaneous consideration of manufacturing process constraints in the generation of initial designs. Included in the project is the development of a core architecture that will permit the "plugging in" of a variety of focused engineering tools, thereby enabling companies to use numerous suppliers as well as develop additional "next-generation" tools.

The American Textile Partnership

The American Textile (AMTEX) Partnership, initiated in mid-1992, is a collaboration of 30 fiber, textile, apparel, and retail companies working in conjunction with the U.S. Department of Energy National Laboratories to provide assistance to the U.S. soft goods industry. The AMTEX Partnership features long range, strategic R&D planning, technology transfer from the public to the private sectors, and an operational framework through which potential projects can be successfully implemented and directed. In January 1994, AMTEX announced a $20 million project – Demand Activated Manufacturing Architecture (DAMA) – designed to develop a computer-based communications, analysis, and simulation architecture to link the entire textile supply chain to an electronic marketplace. This project is expected to reduce an estimated $25 billion a year loss due to stockouts, inventory, and distressed pricing that result from communication inefficiencies within the textile industry.

Center For Electronic Commerce

Combining a focus on small firm assistance and manufacturing information management, the Industrial Technology Institute (ITI) has developed the Center for Electronic Commerce (CEC). The CEC serves as a bridge between government and industry for electronic commerce, supporting the development and broad deployment of electronic commerce within industries through a program of pilots, demonstrations, training and outreach. The CEC works with industry groups (both large customers and their smaller suppliers) to work out the technical and business aspects of effective communication and information sharing and also acts as a hub for sharing information on electronic commerce with other outreach centers across the United States. Examples of CEC pilots include a cooperative project with the Automotive Industries Action Group (AIAG) to develop new ways to manage order release and scheduling of automotive components and a project with the Michigan office furniture industry, a $25 billion industry, to shorten product order-to-delivery time to 5 days.

The National Initiative for Product Data Exchange (NIPDE)

The National Initiative for Product Data Exchange (NIPDE) is an industry-led, government-facilitated partnership that includes companies, corporate consortia, standards organizations and government agencies. Experts detailed to NIPDE from participant organizations are located together at one site to work for a fixed period of time on a standards development plan for digital information agreed to by senior executives from both industry and government. A primary focus of NIPDE has been the coordinated

development and deployment of the Standard for the Exchange of Product Model Data (STEP). NIPDE has identified and catalogued over 400 on-going product data exchange projects accounting for approximately $50-$70 million of annual corporate and government expenditures. NIPDE's "Roadmap" methodology enables companies to evaluate product data exchange strategies, establish plans for their implementation, and monitor how well they help achieve specific business goals. NIPDE's 11 Capability Action Plans (CAPS) coordinate and optimize members' efforts to get early, usable pilot demonstrations of product data exchange capabilities into manufacturing operations. The NIPDE "Master Plan" milestones and schedules help participants review, coordinate, and maximize their own product data exchange efforts. The Department of Commerce hosts NIPDE at NIST's Gaithersburg headquarters.

PDES, Inc.

PDES, Inc., is a 26-member joint industry/government consortium focused on accelerating the development and implementation of the emerging international Standard for the Exchange of Product Model Data (STEP). PDES, Inc. is making substantial progress in influencing and accelerating STEP's development and implementation. Within PDES, Inc., the Development Group focuses on mechanical and electrical/electronics applications and STEP support activities while the Deployment Group conducts pilot projects and develops migration strategies to help members implement STEP in their enterprises. Pilot projects currently underway include AEROSTEP, a project supporting intercompany exchange of product definition data during the development of commercial aircraft design; the Advanced Weapons System pilot project, a demonstration of STEP in an advanced weapons system development environment; and the PreAmp Program, designed to develop precompetitive generic technology using STEP to improve concurrent engineering for the U.S. electronics industry.

The Continuous Acquisition and Life-Cycle Support Initiative

The Continuous Acquisition and Life-Cycle Support (CALS) Initiative is an industry and government strategy to enable more effective generation, exchange, management, and use of digital data supporting the life cycle of a product through the use of international standards, business process change, and advanced technology application. The CALS initiative was started in September 1985 by the U.S. Department of Defense with the goal of enabling the integration of enterprises on a worldwide basis through the development, implementation, and integration of digital information standards for product design, manufacture, and support. The vision is for all parts of a single enterprise to be able to work from a common digital database, in real time, on the design, development, manufacturing, distribution, and servicing of products.

The five primary areas of the CALS initiative are: (1) Technology Development and Demonstration: Develop and demonstrate technologies that can support the integration, management, and secure electronic interaction of large volumes of digitized data, (2) Acquisition Process: Implement policy and procedures, program management guidance, and other contractual processes for major system acquisitions, (3) Technology Infrastructure: Address the way industry and government receive, store, and transmit data, (4) Standards: Integrate selected existing international and national standards, and (5) Training and Outreach: Develop an information dissemination process for effective cultural change needed to implement the CALS initiative throughout government and industry.

Government R&D Initiatives

Within the federal government, there are numerous existing programs explicitly focused on R&D for advanced manufacturing within eight federal agencies, totaling more than $1.3 billion for fiscal 1994. These activities are coordinated by the White House's National Science and Technology Council (NSTC). Within the NSTC, the Civilian Industrial Technology Committee supports advanced manufacturing through its subcommittee on Manufacturing Infrastructure, while the Communications and Information Committee oversees advanced information technology R&D through the High Performance Computing, Communications, and Information Technology (HPCCIT) Subcommittee.

In addition to government involvement in many of the projects cited above, following below is a

summary of key R&D programs sponsored by the federal government related to manufacturing applications for the NII.[3]

The Systems Integration for Manufacturing Applications Program

The Systems Integration for Manufacturing Applications (SIMA) Program at the National Institute of Standards and Technology (NIST) addresses the development of a fully integrated set of manufacturing systems using High Performance Computing and Communication (HPCC) technology. Its primary focus is concurrent product and process design and integrated production planning and control. The centerpiece of the program is the creation of an Advanced Manufacturing System and Networking Testbed (AMSANT) which will support R&D in high performance manufacturing systems and will test high performance computer and networking hardware and software. It will serve as a demonstration and test site for use by industrial technology suppliers and users, and it will assist industry in the development and implementation of voluntary standards.

In addition, the SIMA program includes a standards-based data exchange effort for computer-integrated manufacturing that will focus on the improvement of data exchange among computer-aided design, process, and manufacturing activities. Applications may include enterprise integration for manufacturing applications, integrated product/process design, simulation and agile manufacturing. Results will be made available to U.S. industry through workshops, training materials, electronic data repositories and pre-commercial prototype systems that can be installed by potential vendors for test and evaluation. Lastly, NIST will distribute Standards Reference Data, technical information, and digital product data designs via digital library technologies.

Technologies Enabling Agile Manufacturing

To support U.S. industry's efforts to meet the manufacturing challenges of today and tomorrow, the U.S. Department of Energy (DoE) facilities are teaming with industry in the development of Technologies Enabling Agile Manufacturing (TEAM). The TEAM project has a twofold mission: collaboration with industry to define critical technology needs, and direct access to the vast DoE scientific and engineering resources—people and facilities—that have created state-of-the-art manufacturing systems. DoE's world-class manufacturing resources will unite with industry to:

- Define an integrated set of U.S. manufacturing requirements;
- Form project teams to address specific technological needs and opportunities throughout the manufacturing life cycle;
- Promote awareness of available and potential solutions within both the private and government sectors;
- Advance current technologies and collaborate to develop new solutions;
- Demonstrate and install enabling technologies that will benefit a broad spectrum of U.S. industries without impeding the competitive process; and
- Provide a virtual enterprise of technology centers, accessible to all partners.

The TEAM project thrust areas are Production Design and Enterprise Concurrency, Virtual Manufacturing, Manufacturing Planning and Control, Intelligent Closed-Loop Processing, and TEAM Integration. In one project, TEAM will work with the Financial Services Technology Consortium to develop billing and payment systems using the NII for the manufacturing industry.

Manufacturing and Design Engineering Program

The Manufacturing And Design Engineering (MADE) program of the Advanced Research Program Agency (ARPA) focuses on the development and demonstration of key software elements for Integrated Product/Process Development (IPPD) and agile manufacturing applications for the NII. The primary emphasis is on mechanical parts and electro-mechanical assemblies, where today's automation environment is neither integrated nor flexible compared to

[3] These projects were selected from both the Committee on Applications and Technology and the High Performance Computing, Communications, and Information Technology (HPPCIT) subcommittee's inventories.

electronics design and manufacturing. As a result, the program addresses the following areas:

- Development of tools for conceptual design that provide a spreadsheet-like capability for iterative optimization of product and process characteristics. MADE will initially focus on design for assembly and assembly process planning, simulation, and control.
- Development and demonstration of tools for interoperability, such as self-describing, reusable, sharable product and process representations. In addition, MADE will demonstrate unambiguous interchange of geometry, dimensions, and tolerances in machine interpretable form, and will develop productivity-enhancing capabilities for capturing and sharing data requiring human interpretation, such as design intent. These activities will provide a foundation for enhancement of emerging product data interchange standards such as STEP.
- Demonstration of a scalable capability to share multiple types of distributed information among networked applications that were not explicitly designed for interoperability. MADE will prototype a layer of network integration services using intelligent agents to facilitate interactions among coarse grained objects (encapsulated legacy systems), fine grained objects (such as new MADE tools) and man-in-the-loop applications. Initial services will include brokering of services for engineering analysis and manufacturing processes, limited electronic commerce support, and multi-media interchange of information among engineering and manufacturing applications.

Agile Manufacturing Initiative

Sponsored by ARPA and the National Science Foundation, the Agile Manufacturing Initiative includes a prototype of an information infrastructure to support distributed concurrent engineering, flexible manufacturing, and electronic commerce in manufacturing applications. The vision of agile manufacturing is to enable "virtual companies" to be formed by linking design and manufacturing operations that are physically distributed among a group of companies. The program has three components: (1) an agile manufacturing network ($10M), which will provide access to design and manufacturing applications over both Internet and commercial networks, (2) agile manufacturing research institutes ($5M), which will work with industry groups in important sectors to develop a deep understanding of the business principles and practices for lean/agile manufacturing, and (3) pilot programs ($13M) to demonstrate use of the technology and business practices to achieve improvements in cycle time, cost, quality, and responsiveness to change.

Part III: Where Do We Want to Be?

The national vision of an advanced NII that supports manufacturing is one of widely accessible and interoperable communications networks; easy-to-use applications that are capable of running on whatever types of computers are available; a diverse collection of digital libraries, information databases, and services; and trained operators and support people. Achieving this vision will require both short and long term goals.

Short Term Goals:

A short term goal of the NII is for manufacturers, in particular small- and medium-sized ones, to have sufficient information to make adequate investments in both existing and advanced information technologies for the purpose of modernizing current manufacturing practices as quickly as makes business sense. Continued and expanded investment in automation and networking technologies will enable companies to streamline business and manufacturing processes, making them more efficient, effective, and competitive.[4] Through the use of information technologies, management and shop-floor workers alike increase their familiarity and comfort with information technologies, begin to see the benefit of treating information as a strategic asset, and most importantly, place themselves in position to take advantage of existing NII tools and services to solve real business problems and meet increasingly competitive business challenges.

[4] As noted earlier, the use of information technologies and the advanced NII is important to business modernization and competitiveness, but it is not the only important factor. Companies must also make changes in management, corporate culture, organizational design, and other "nontechnical" business factors throughout the entire manufacturing enterprise in order to remain competitive.

A second and related goal is for manufacturers to use existing NII tools and services in combination with automation and networking technologies to advance their business modernization efforts. NII tools for analysis and simulation, quality assessment, and data management and NII services which enable automated bidding, data conversion, and on-line searches of databases and directories, enable companies to streamline manufacturing operations and activities. The use of information technologies in combination with NII tools and services, enables manufacturers to better understand their own and other's information requirements and flows and to see the value of an advanced information infrastructure to their business operations. As a result, the risk and uncertainty of additional investments is reduced while the role of information as a strategic asset is further clarified.

To realize these short-term goals, initial NII tools and services should support the following manufacturing functions:

- Transmission, translation, exchange, and down-loading of electronic design Initial Graphic Exchange Specification, product (STEP), and business transaction data Electronic Data Interchange;
- Electronic bidding and proposal, billing and payment processes;
- Conversion and translation of data, including legacy (Computer-aided-xxx) data;
- Automation of engineering and design change;
- Distribution of design and production functions;
- Search, identification, location, communication, and coordination of suppliers, customers, partners, and others; and
- Advanced planning concepts and implementations.

To be effective, initial NII tools and services need to be transparent, easy to use, secure, and cost effective. A sample of initial tools and services is given below:

While some tools and services already exist, others will need to be created. Almost all will need to be improved, enhanced, and extended as the advanced NII evolves. In addition, as companies increase investment in information technologies and become more accustomed to NII capabilities, additional, unforeseen tools and services will be needed. An additional short term goal, therefore, is the design, development, testing, implementation, and use of new NII applications for manufacturing. Most applications will be driven by users who will work together and with vendors to define information requirements and to develop, implement, and test them.

Table 3. Examples of Initial Tools and Services

Tools	Services
process analysis tools	access to government services
data storage, management, retrieval, and tracking tools	access to government procurement information
electronic mail	forums and bulletin boards
design tools	best practices databases
quality assessment tools	data conversion services
online search tools	online training and outreach
modeling and simulation tools	electronic bidding networks and services
software toolkits and libraries	teleconferencing services
benchmarking tools	directories (white and yellow pages)
management and organizational design tools	parts catalogues
planning tools	referral services

Whether in small or large companies, the adoption and deployment of manufacturing technologies and the use of NII applications will be incremental.

A fourth short term goal is to hasten this process, encouraging companies to adopt technologies and use the NII faster than has been supported by the free market in the past. At the same time, it is imperative that companies think strategically about their investments in infrastructure technologies, tools, and services, and make all investments in the context of a long-term business strategy that places emphasis on the role of the information management and use in future economic competitiveness. Demonstration and testing of advanced manufacturing techniques such as enterprise integration and "agile" manufacturing will help companies see the benefits of the seamless exchange and use of information throughout an enterprise while providing a model for manufacturers to build toward. It will also encourage all investment to be made in the context of a long term business strategy, so as to avoid "islands of automation" or stove-pipe situations. As a result, to ensure the goal of hastened yet strategic investment in information technologies and NII tools and services, U.S. manufacturers, information technology vendors, and the federal government must encourage the development and implementation of advanced manufacturing pilot projects and testbeds.

Long Term Goals

Enabling U.S. manufacturers to compete and win in world markets is the ultimate goal of developing and implementing advanced NII applications in manufacturing. There are a number of technical and non-technical issues that need to be addressed for the vision of an advanced NII in manufacturing to become a reality. An essential goal is the establishment of standards for product and business data, network interfaces, and business and engineering practices.

While product and process technological innovation is important to economic success, standards are essential. Without standards, effective and efficient cooperation and collaboration cannot occur. Indeed, "in an automated environment, concurrent engineering is impossible without standards [Carver, p. 3]." The same can be said for agile and virtual manufacturing as well as electronic business and financial transactions.

Standards enable rapid communication and iterative decision-making. While protection of intellectual property and proprietary interests are critical to increase competition and innovation, they sometimes can provide unnecessary barriers to market competition. For example, some proprietary data formats, incompatible hardware peripherals and reporting requirements, and rigid supply and distribution networks inhibit rather than enhance collaborative activities and restrict rather than improve the speed, accuracy, and flexibility of supplier and consumer transactions. In addition, standards lower the barriers to entry by small- and medium-sized firms, frequently shut out of established markets by entrenched trading partners. Lastly, they reduce the risk of investing in complex products and systems, enabling accelerated market penetration and diffusion of new product and process technologies. For all these reasons, the establishment of international standards for data formats, network interoperability, and business and engineering practices is vital to the long term success of an advanced NII.

Just as the private sector has the major responsibility for building the NII, it is the private sector which must play a vital role in standards development and implementation. The federal government can and should aggressively promote action on standards by the private sector and assist in their development and use. Other critical long-term goals include developing the ability to:

- Understand how information is absorbed, sorted, accessed, and used;
- Scale prototype systems;
- Ensure data security and integrity, and maintain intellectual property rights;
- Verify (certify) conformance to and compliance with NII standards;
- Use benchmarking and other metrics to assess competitive position and evaluate alternative services and suppliers;

- Provide adequate education, training, and outreach to overcome social, managerial, and economic barriers (including financial impact and business justification) to use of the NII; and
- Maintain long-term research and development and commitment to advanced manufacturing technologies, through support of the Manufacturing Infrastructure subcommittee of the NSTC's Civilian Industrial Technology Committee, the High Performance Computing, Communications and Information Technology Subcommittee of the NSTC's Computer and Information Committee, and other strategic R&D programs.

Part IV: How Are We Going to Get There?

For the NII to succeed, the private sector must own and operate it; develop, design, and implement its applications; and make the vast majority of investments. There are several significant barriers, some technical, some cultural, and some financial, to achieving the NII vision. For example, most of the 370,000 small- and medium-sized manufacturers in the United States, who compose nearly 98 percent of all manufacturing firms, have neither the expertise, time, nor resources to modernize their manufacturing processes without some assistance. Moreover, small and large firms alike are inhibited by the difficulty they find identifying and understanding technology trends, generating adequate investment decisionmaking and strategic planning models, implementing new technologies and migrating from old (legacy) systems, and, most importantly, developing a comprehensive business case capable of tying all these factors together.

Inexperience with computers and other information technologies and the perceived threat of advanced manufacturing applications on traditional ways of performing work present additional barriers to achieving the NII vision in manufacturing. Accordingly, user acceptance of, and comfort and familiarity with information technology and its opportunities for improving manufacturing competitiveness and economic performance are necessary to developing meaningful advanced manufacturing NII capabilities.

Moreover, manufacturers must increase education and training efforts to ensure that workers and managers are comfortable with and ready to use the NII.

The federal role is to help the private sector get beyond these and other barriers to making the advanced NII a reality. The federal government must provide an environment in which the private sector can take the lead, seeking to remedy market failures such as low investment or adoption of information technologies, standards, or R&D where necessary.
To make the NII vision in manufacturing a reality and to meet both short and long term goals, the following issues need to be addressed and answered through private and public actions:

Issues and Questions to be Addressed

- The continued modernization of manufacturing processes, in particular through incremental investment by small- and medium-sized manufacturers in appropriate manufacturing technologies, is fundamental to building a strong, competitive, sustainable industrial base in the United States. Early indications show that programs such as the Manufacturing Extension Partnership (MEP) and other state and local efforts are successful at helping manufacturers make investments and adopt appropriate manufacturing technologies, including communications equipment and computer hardware and software applications for the NII. Should the federal government, building on the successes of the MEP, broaden the scope and reach of the MEP, turning it into a national program capable of assisting small- and medium-sized manufacturers throughout the United States in their preparation for the use of the NII for manufacturing?
- In the new manufacturing paradigm, the factors that determine competitiveness – flexibility, responsiveness, time-to-market, cost, and quality – all depend on the efficient manipulation, control, management, and use of information. For this reason, information is a company's key strategic asset. While many companies want to modernize their equipment and processes, they often find

difficulty in procuring, installing, and configuring new equipment to work with old equipment and in thinking about short-term investments in new equipment and capabilities in the context of a long-term, enterprise-wide investment strategy. To facilitate the investment process, should the federal government increase the scope of the MEP to assist small- and medium-sized companies with their long-term strategic planning and investment decision-making activities?

- Standards for product data exchange, electronic commerce, and interoperabiltiy are essential to the development and use of the NII in manufacturing. Currently, however, there are no generally accepted methodology or data format standards to allow easy exchange of data (both engineering and business) between U.S. companies within the same industry or across industries. In addition, information technology advances for manufacturing systems occur at very frequent intervals and there is concern that the standards development process as it is today cannot keep pace with the needs of the manufacturing industry. The federal government can accelerate the standards development and acceptance process by providing strong technical support for standards development and by demonstrating the soundness of technical ideas through rapid prototyping, demonstration of feasibility, and other implementation and validation activities. In which areas are the development and demonstration of the technical underpinnings of manufacturing-related standards for the NII most needed? Does continued federal investment in product data standards (STEP), electronic commerce standards (EDI), and interoperabiltiy standards (OSE) make sense? Is there a need for an overarching standards framework that ensures that manufacturing applications for the NII are compatible?

- The Committee on Civilian Industrial Technology (CIT) of the National Science and Technology Council (NSTC) has identified several areas as critical to the manufacturing infrastructure. These areas include: Agile Manufacturing, Manufacturing Systems Integration, Manufacturing Technology Deployment, Intelligent Sensors and Controls, and Rapid Prototyping. In addition, the Committee on Information and Communications (CIC) of the NSTC oversees R&D for the Information Infrastructure more broadly. What are the specific technical requirements that industry needs to develop, implement, and use manufacturing applications for the NII? Which areas of R&D will stimulate most rapidly the development and use of applications for the NII in manufacturing? What are the best candidates for federally sponsored demonstration projects and test beds? Which federal agency or agencies should coordinate and lead the effort to build and test manufacturing applications for the NII?

- While the federal government performs a great deal of R&D and provides demonstrations and test beds, it is the private sector that turns the results of both public and private R&D into commercial products and processes. In the capital intensive, pre-production, latter stages of R&D, however, capital markets often find it difficult to properly assess the risk-return ratio (i.e., expected value) of further investment in product or process development and therefore often do not provide resources to test the commercial viability of high risk products and processes. To what extent is this a problem in manufacturing? Is there a government role in helping capital providers to accurately determine the risk-return ratio of investment in the latter stages of high risk product and processes development?

- In the information age, a highly skilled, flexible, retrainable workforce is essential to economic competitiveness. The NII can be used to provide just-in-time, remote, tailored, multi-media education and training applications. (See, for example, "A Transformation of Learning: Use of the National Information Infrastructure for Education and Lifelong Learning"). The dynamic nature of the manufacturing sector necessitates the existence of adequate mechanisms for the identification of current and future trends and needs of U.S manufacturers, assessment of the skills required to perform new tasks and use new manufacturing equipment, and development and delivery of focussed education and training programs directly to workers on the shop floor in a timely and effective manner. To what extent should the federal government play a role in

developing mechanisms for the education and training of the U.S. workforce to meet manufacturing needs? Should the federal government guarantee that all U.S. manufacturers, regardless of size, have access to adequate education and training resources? Which federal agency or agencies should be responsible for these activities?

- For manufacturers to use the NII they must be assured that their transactions will be secure, timely, verifiable, and unaltered. To what extent is the safety, reliability, security, and maintenance of the NII a federal responsibility?

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Electronic Commerce and the NII

DRAFT FOR PUBLIC COMMENT

"Electronic Commerce integrates communications, data management, and security services, to allow business applications within different organizations to automatically interchange information. Communications services transfer the information from the originator to the recipient. Data management services define the interchange format of the information. Security services authenticate the source of information, verify the integrity of the information received by the recipient, prevent disclosure of the information to unauthorized users, and verify that the information was received by the intended recipient."

Source: Information Infrastructure Technology and Applications (IITA) Task Group, National Coordination Office for High Performance Computing and Communications, February 1994, pp. 13-4

PART I: What Is the Application Arena?

Description of Electronic Commerce

The telephone, fax, and electronic mail have provided faster, cheaper, and more reliable communication of business data within and between commercial entities. Great distances and multiple time zones are no longer barriers to business communications; the challenge now is how to respond to and use an ever-increasing flood of data from diverse sources in a timely and effective manner. The stakes are high: vital information from the office next door or the other side of the world may be lost or unnecessarily delayed in the flood.

Many businesses are coping with the data flood by shifting much of their routine data processing and business transactions to automated, electronic information systems. However, differences in information systems require that trading partners frequently translate from one system to another manually, greatly reducing both the speed and the reliability of information exchange. In addition, while standards for Electronic Data Interchange (EDI) enable fast, accurate exchange of routine, relatively simple business transactions between different automated information systems, EDI requires rigid agreements about the structure and meaning of data. These agreements are often expensive, inflexible, and difficult to maintain, especially in a rapidly changing business environment.

Electronic Commerce is the evolution of EDI into other types of data and transactions. An advanced national Electronic Commerce capability will be comprised of interconnected communications networks; advanced computer hardware and software tools and services; established business transaction, data exchange, and interoperability standards; accepted security and privacy provisions; and suitable managerial and cultural practices. This infrastructure will enable diverse and distributed companies throughout the nation to rapidly, flexibly, and securely exchange and, more importantly, use information to drive their business processes. As a result, people—who are needed to creatively solve complex business problems—can be taken out of the loop of routine data processing.

An advanced NII for Electronic Commerce can support activities such as the following:

Electronic funds transfer – extending and completing the procurement process by providing buyers the ability to rapidly and cost-effectively make their payments to sellers and shippers with less financial risk and fewer errors, while reducing paper handling and storage.

Government regulatory data interchanges – collecting formatted data from (and returning data to) various communities to enable the government to carry out its mandated responsibilities: e.g., organizations that transport hazardous materials, corporations and banking institutions that submit financial reports, and State public health officials who report health statistics and epidemiologic incidents.

Collaborative engineering – providing for early evaluation of engineering designs to ensure manufacturability, reliability, maintainability, and other "-ilities." This may involve massive amounts of highly complex engineering data, as well as extensive, non-routine interactions among people.

Enterprise integration – extending integration throughout a company and into other trading partners. Business Process Reengineering is needed to identify business processes which can be improved (or eliminated entirely) by improving communication within a company or by outsourcing to other companies. The result is the Virtual Enterprise, which provides vertical integration of companies with their suppliers as well as horizontal integration of segments of a company.

Computer-supported collaborative work – expanding collaborative activities from engineering into many other business activities, such as supporting joint development of requirements, maintenance documents, etc., within or across companies (e.g., just-in-time inventory control). The intent is to remove the barriers (time, space, information complexity, etc.) that inhibit creative interactions among people.

Electronic Commerce can combine the advantages of computers (speed, reliability, high volumes of data) with the advantages of people (creativity, flexibility, adaptability). Electronic Commerce can enable people to review, analyze, add value, and sell a wide variety of products that are represented electronically, such as reference material, textbooks and training materials, entertainment, and software. Electronic Commerce is not limited only to business transactions – it also applies to exchanges of ideas and opinions, as well as the amassing and sorting of information.

The successful extension of Electronic Commerce into these more complex (and rewarding) areas is dependent on the integration of communications, data management, and security services into a ubiquitous, user-friendly, easily accessible national electronic marketplace that encourages and enables the seamless exchange of information for social and business transactions – for all companies.[1]

In sum, Electronic Commerce differs from traditional commerce primarily in the way information is exchanged and processed. Traditionally, information has been exchanged through direct, personal contact or through the use of the phone or postal systems. In Electronic Commerce, information is conveyed via a digital communications network, computer system, or some other electronic media. In addition, the information accompanying a typical traditional business transaction is usually acted upon by individuals involved in the transaction, whereas with Electronic Commerce much of the transaction is automated. At a minimum, Electronic Commerce increases the speed, accuracy, and efficiency of business and personal transactions.

What Are the Benefits of Electronic Commerce Applications in the NII?

An advanced NII that supports Electronic Commerce applications will provide benefits in a number of areas:

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[1] Electronic Commerce will affect all types of business transactions and personal activities. As a result, Electronic Commerce applications are described to some extent in each of the applications strategies white papers. For a detailed discussion of the potential influence of Electronic Commerce on the manufacturing industry, see the white paper: Manufacturing and the NII.

- **Reduced costs to buyers** from increased competition in procurement as more suppliers are able to compete in an electronically open marketplace;
- **Reduced errors, time, and overhead costs in information processing** by eliminating requirements for re-entering data;
- **Reduced costs to suppliers** by electronically accessing on-line databases of bid opportunities, on-line abilities to submit bids, and on-line review of awards;
- **Reduced time to complete business transactions**, particularly reduced time from delivery to payment;
- **Creation of new markets** through the ability to easily and cheaply reach potential customers;
- **Easier entry into new markets**, especially geographically remote markets, as the playing field becomes more level between companies of different size and locations;
- **Better quality of goods** as specifications are standardized and competition increases, and **better variety of goods** through expanded markets and the ability to produce customized goods;
- **Faster time to market** as business processes are linked enabling virtual elimination of time delays between steps and the engineering of each subprocess within the whole process for seemingly seamless processing;
- **Optimization of resource selection** as businesses quickly form cooperative teams to better tailor capabilities to work opportunities to increase chances of success, to share economic successes more broadly, and to give the customer a mix of capabilities more exactly meeting his requirements. Teaming may happen at either the company or individual level, creating a just-in-time "virtual" resource for delivery of the right human and business resources for a job. In addition, the **workforce can be better utilized** by freeing skilled labor from routine activities enabling them to focus instead on customer service and more complex duties;
- **Reduced inventories** and a related reduction of risk of obsolete inventories as the demand for goods and services are electronically linked through just-in-time inventory and integrated manufacturing techniques;
- **Ability to undertake major national programs** such as national health care where the cost and personnel needed to manage a manual or disjoint automated system could be prohibitive or unreasonable;
- **Reduced overhead costs** through uniformity, automation, and large-scale integration of management processes which enable flatter, wider, more efficient processes; and
- **Reduced use of ecologically damaging materials** through electronic coordination of activities and the movement of information rather than physical objects.

What is the Public Interest in Promoting the Application?

Productivity increases are essential to the long-term economic viability of the U.S. economy. Increases in productivity enable companies to create, provide, and maintain goods and services using less resources. As a result, profits rise, additional resources are freed to be invested in the sources of future economic growth and even greater productivity, and, rounding out the virtuous circle, companies continue to grow and profit. The ultimate beneficiary, of course, is the U.S. worker whose economic security is strengthened and whose standard of living continues to rise.

Since the early 1980's U.S. companies have been pumping money into information technologies as one way to boost productivity. However, despite investments of over $1 trillion during this period, the resulting economic benefits have been disappointing: overall U.S. productivity grew at an annual rate of only 1.0 percent, while during a similar period, Japan's productivity increased 3.0 percent per year, Germany's 1.8

percent per year, and Korea's 5.7 percent per year.[2,3]

Table 1. Annual Growth In Gross Domestic Product per Labor-Hour for Selected Sectors of the U.S. Economy, 1979–1989

Industrial Sector	Average Annual Growth per Labor Hour (percent per year 1979–1989)
Manufacturing	3.33
Service Producing	0.84
Government	0.53

Source: U.S. Department of Commerce, Bureau of Economic Analysis, 1991. *Survey of Current Business*, April, Tables 6.2 and 6.11.

An advanced NII which supports Electronic Commerce applications will help U.S. companies increase productivity by enabling rapid business transactions, data and information exchanges, and organizational changes. Through the ability to handle tremendous volumes of transactions and the ability to amass, analyze, and control large quantities of specialized data, organizations will be able to improve efficiency and accuracy, and reduce costs, while providing faster, more reliable, and more convenient services.

Most importantly, in combination with changes in management practices, organizational design, corporate culture and other non-technical advancements, U.S. companies can reengineer their business processes, and then use the NII to take greater advantage of the productivity potential of their current and future information technology investments. Electronic Commerce will increase efficiency by improving human access to information, and increasing the need for human judgement based on that information.

The immediate effect will be to enhance the dynamics of competition in the U.S. economy. With the ability to perform Electronic Commerce anywhere at anytime, smaller firms will be able to enter and participate at less cost and more efficiently in new markets, and larger firms will be able to evaluate, select, and work with other companies more readily than is possible today. In addition, with an advanced NII in place, new ways of doing business and new forms of economic activities will develop, including telecommuting, worldwide research networks, global sourcing arrangements, large-scale development and sharing of new databases, new training and education capabilities, faster response innovation systems, and disaggregated alliances or networks of companies.

As U.S. companies use Electronic Commerce to boost productivity, they will be able to maintain and expand their share of international markets. At present, the United States maintains a large trade surplus in computer software, communications equipment, financial services, and other information-intensive manufacturing and service industries. Catching up in some international markets and expanding market share in others is critical to domestic economic growth, as the export market will be the largest single source of potential value-added to the GDP in the future.

In addition to their importance to international trade, communications equipment and computer hardware and software drive the information infrastructure, providing the connectivity, tools, and services that other companies use to produce their products and to ensure a close working relationship among their suppliers, customers, and partners. In the face of shortening technology and product life cycles and increasing technological complexity, the ability to integrate highly sophisticated, next-generation components and associated services into downstream products and services requires close working relationships among component and end-product manufacturers and service suppliers. Historically, this synergy has been difficult to achieve among U.S. companies and their suppliers. An advanced NII will facilitate and encourage these relationships.

[2] Productivity is measured as the average percent change in real gross domestic product (GDP) per employed person for the period 1975–1991. Source: U.S. Department of Labor, Bureau of Labor Statistics.

[3] Some economists have concluded that any apparent lack of productivity growth may be due to deficiencies in the way we measure productivity. For an excellent summary of the current literature and a thorough assessment of the "Productivity Paradox," see Brynjolfsson, Erik, "The Productivity Paradox of Information Technology," *Communications of the ACM*, December 1993. In this study the author argues, "that the shortfall of IT productivity is as much due to deficiencies in our measurement and methodological tool kits as to mismanagement by developers and users of IT." He later concedes, however, that, "although it is too early to conclude that the productivity contribution of IT has been subpar, a paradox remains in the difficulty of unequivocally documenting any contribution, even after so much effort."

Finally, as information and information exchange become more valuable to economic performance, those countries that develop an effective advanced information infrastructure will gain competitive advantage in global markets. Instead of just chasing low-wages around the globe, as has been the trend in the recent past, companies increasingly will choose to locate and invest in countries whose infrastructure and highly-skilled workforce are able to handle the rapid and efficient control and dissemination of information and the integration of diverse business operations. Consequently, an effective advanced NII and trained workforce in the United States can make the United States the country of choice for investment, with enormous and lasting positive impact on the national economy.

Evidence of the Benefits

Many companies in several industries have experienced the benefits and realized the need to use Electronic Commerce to survive. Large companies such as Sears, General Motors (GM), and Wal-Mart have championed electronic trading practices for their suppliers. Indeed, in some industries EDI has become a virtual necessity for doing business. Some examples of the benefits of Electronic Commerce are given below:

In the 1980's, Wal-Mart Stores, Inc., experienced explosive growth in sales, rising to number one in the U.S. retail business. Despite its rapid growth, Wal-Mart's investment of half a billion dollars in computer and satellite communications networks, bar code systems, scanners, and other "quick response" equipment linking each point-of-sale terminal to distribution centers and headquarters in Bentonville, Arkansas, enabled the company to maintain high service levels and increase sales while preserving one-fourth the inventory investment. By empowering its individual stores to order directly from suppliers, even overseas, Wal-Mart stores reduced inventory restocking time from an industry average of six weeks to thirty-six hours. Moreover, by tracking every sale to see what was selling and what was not, Wal-Mart stores were better able to keep their stores well-stocked while maintaining tight inventories and low prices [Davidow, pp. 23–24].

In building a brand new facility in which to manufacture its Saturn cars, General Motors developed an information infrastructure to enable Saturn and its numerous suppliers to operate as one company. Through the implementation of a production scheduling database and the use of electronic data interchange, Saturn and its suppliers reduced overhead in all organizations, increased cooperation, and broke one of the oldest rules in any corporation's unwritten rule book: treat vendors as adversaries. Located in Spring Hill, Tennessee, the Saturn plant includes an online manufacturing database which is accessible by component suppliers who do not wait for GM to send a purchase order, but simply consult the car maker's production schedule, included in the database. In this process there is no paper—no purchase order and no invoice. After the parts are shipped, the vendor sends an electronic message to Saturn saying, in effect, "These are the parts we have sent you." When the box of goods arrive, the receiving clerk scans the bar code printed on it with an electronic wand. The computer can then tell the receiving clerk to what part of the plant the goods should go. The scanning also initiates payment to the vendor [Hammer, pp. 90–91].

Over the past decade, the banking and financial industries have invested heavily in automation and networking technologies to handle and process electronically an ever-increasing number of financial transactions. For example, the Clearinghouse for Interbank Payment Systems coordinates daily bank-to-bank transactions worth nearly $2 trillion while the nation's network of more than 75,000 Automated Teller Machines (ATMs) handles more than 6 billion transactions per year. In addition, one analysis of the New York Stock Exchange suggests that electronic trading saves stock buyers and sellers hundreds of millions of dollars annually. Examples of the effect of Electronic Commerce on specific financial institutions abound: Through the use of information technologies, Visa's peak capacity for processing credit card transactions grew from 30,000 per day in 1978 to over 1.4 million per day in 1991, while its response time for authorizations dropped from 5 minutes in 1973 to 1.1 seconds in 1991; through the deployment of an ATM network in 1977 Citibank increased its market share from 4 percent to 13.4 percent; by installing a computer-based network to resolve credit card disputes, Mellon Bank reduced its backlog of customer complaints from 5,200 to 2,200, resolving them in 25 days on average (versus 45 days previously) [National Research Council, pp. 83–84 and Davenport, p. 54].

Through the use of just-in-time inventory control and total quality management practices, Harley Davidson reduced manufacturing cycle time for motorcycle frames from 72 days to just 2, while increasing final product quality from 50 percent to 99 percent; Digital Equipment reduced overall inventory from 16 weeks to 3, while reducing its defect rate from 17 percent to 3 percent; and 3M attained a 70-fold reduction in critical defects, appearance defects, and packaging problems [Davidow, p. 94].

The Defense Medical Logistics Standard Support (DMLSS) system has embraced Electronic Commerce concepts of business process redesign and EDI to obtain an estimated $3.2 billion savings over 12 years from an investment of $120 million. Savings come from reduced inventories and the leverage of the civilian health care supply industry to streamline DoD operations.

The U.S. Customs Service, one of the leaders in the federal sector for adoption of EDI, today processes 94 percent of all customs declarations electronically and collects 60 percent of all duties electronically. By moving from paper to electronic declarations, Customs reduced error rates from 17 percent to 1.7 percent, a whole order of magnitude. In addition, it saves an estimated $500 million in processing costs each year while increasing annual productivity an estimated 10 percent each year.

PART II: Where Are We Now?[4]

As seen above, many companies and government agencies use Electronic Commerce applications to facilitate internal operations and interact seamlessly with their trading partners. While a wide variety of transactions occur electronically already, the performance of Electronic Commerce applications usually requires highly structured, previously established arrangements and, for the most part, dedicated lines and/or Value-Added-Networks (VANs). The resulting costs and necessary lead times frequently create barriers to investment in and widespread use of Electronic Commerce applications by small and medium-sized companies, and inhibit the expansion of Electronic Commerce beyond large companies and their major trading partners.

Despite these barriers, the electronic marketplace is forming at a rapid pace. By the end of 1994, more than 10,000 companies will be offering information and services for sale over a combination of Internet and VAN service providers. Their ranks are expected to swell to 100,000 by 1997 and 1 million by 1999. In addition, the Internet is already making some form of Electronic Commerce an economically viable option for many companies. Today, the Internet connects some 10 million users in over 130 countries, and at current growth rates it will link to an additional 15 million users by 1995. While the Internet is useful for electronic mail, bulletin boards, and file transfer, it has a number of limitations that must be overcome before it can be deemed suitable for commerce. Some commonly expressed concerns include reliability, security, scalability, and ease-of-use. These problems could be more easily addressed if the Internet were run as a business enterprise; the enterprise would be accountable to customers from whom it would receive payments for specified services rendered.[5]

Electronic Commerce usually happens as a set of evolutionary implementations. The early implementations focus on the introduction of electronic technologies to add functionality and operational effectiveness (i.e., automate business processes) by connecting computers and applications with electronic tools such as bulletin board systems, groupware, databases, e-mail, electronic directories, imaging, and graphics. The second phase moves beyond automation to complete business process reengineering, where major benefits are realized from the integration of the business processes. Business process reengineering, facilitated by Electronic Commerce, eliminates time and distance constraints, leading to double digit or higher annual returns on investment as well as increasing cycle time by an order of magnitude or better.[6] Obtaining Electronic Commerce benefits is more like a journey rather than a destination. With each increase in the efficiency of business pro-

[4] Much of this section is excerpted from "Electronic Commerce on the Internet," by Robert Neches, et al.

[5] Potential solutions to these and other concerns about using the Internet for Electronic Commerce are explored in "Electronic Commerce on the Internet," by Robert Neches, et al.

[6] For an excellent discussion of the role of information technology in business process reengineering see Davenport, *Process Innovation: Reengineering Work Through Information Technology*.

cesses, new bottlenecks are identified, studied, and overcome yielding a new level of benefits. An improved NII will establish an environment conducive to speeding up this evolution.

The computers, networks, standards, interoperability, accessibility, training, and other components of the NII are the raw materials used to build the national Electronic Commerce capability. Once the tools for Electronic Commerce are nationally available and companies are comfortable using them, organizations will be able to concentrate on a re-examination of business processes rather than working to overcome technology barriers. As a result, the realization of the benefits possible through Electronic Commerce will be accelerated by implementation of the NII.

Federal Goals

From its sheer size, the government's adoption of a redirection in business practices can create a force that can sway business practices throughout the nation. At present, there are numerous pockets of expertise in the federal government. Most importantly, the Administration has made the development and implementation of Electronic Commerce throughout the federal government a top priority, with the President asserting personal leadership in this area by signing an Executive Memorandum outlining federal goals for "Streamlining Procurement Through Electronic Commerce" dated October 26, 1993. That memorandum provides the following milestones:

- "by March 1994, define the architecture for the government-wide Electronic Commerce acquisition system and identify executive departments or agencies responsible for developing, implementing, operating, and maintaining the federal electronic system;
- "by September 1994, establish an initial Electronic Commerce capability to enable the federal government and private vendors to electronically exchange standardized requests for quotations, quotes, purchase orders, and notices of awards and begin government-wide implementation;
- "by July 1995, implement a full-scale federal Electronic Commerce system that expands initial capabilities to include electronic payments, document interchange, and supporting databases; and
- "by January 1997, complete government-wide implementation of Electronic Commerce for appropriate federal purchases, to the maximum extent possible."

This implementation schedule should be accelerated where practical.

By creating and completing an initiative such as the President's Executive Memorandum, the government will signal strong leadership for the country's adoption of Electronic Commerce.

In addition, the National Performance Review, conducted by Vice President Al Gore, has proposed to reengineer many current government services and information dissemination processes through the introduction of Electronic Commerce applications.[7] Many smaller businesses and government agencies, however, are waiting for Electronic Commerce applications to become more prevalent before they make their investments, citing the desire to avoid prohibitive trail-blazing costs that are always incurred by the leaders. Legacy systems and a large installed base provide further barriers to Electronic Commerce. In addition, some organizations, even if large, are at the end of an information chain involving many organizations which have handled the information before it gets to them; the benefits from conversion to electronic data handling may not make sense until that data is delivered in electronic form.

Federal Activities

The following is a small sample of current activities within the federal government:

The Executive Office of the President has established the Federal Electronic Commerce Acquisition Team to define the Electronic Commerce architecture called for in the President's Executive Memorandum. Representatives from over a dozen federal agencies and departments participate on this team, which is co-chaired by the General Services Administration and the Department of Defense.

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[7] For more detail on federal initiatives to use Electronic Commerce improve the collection and dissemination of information and the provision of government services see the white paper: Government Service Delivery: Reengineering Through IT.

The General Services Administration (GSA), Information Resource Management Services (IRMS), is engaged in several government-wide Electronic Commerce initiatives which should have a major impact on the way the federal government conducts business with the private sector. These activities include:

- The support of the President's Electronic Commerce Executive Order by providing procurement, automated data processing, and telecommunications technical support and by serving as co-chair of the Federal Electronic Commerce Acquisition Team.
- The redesign and implementation of an automated procurement system which will start with the preparation of a purchase requisition and include the electronic transmission of a purchase order, either using EDI, e-mail, or fax. Once the order is completed the vendor will electronically transmit its invoice, which will be electronically matched with the purchase order and receiving report. The payment to the vendor will then be made through EFT.
- The establishment and maintenance of the IRMS Bulletin Board which contains Multiple Awards Contract information is undergoing enhancements to enable federal agencies to directly place purchase orders.
- The development and introduction of emerging technologies into the government-wide infrastructure through Master Contracts for products and services, and the development of critical multiagency services. A number of specific initiatives are likely to support Electronic Commerce. These may include service ordering and billing, and X.435 prototype and operational system development, distributed directory services, registration services, and security certification services.

The Office of Management and Budget has established an E-Mail Task Force (EMTF), to develop a plan of action for promptly establishing a government infrastructure for interagency e-mail. The plan will support mail-enabled applications such as electronic filings, Electronic Commerce, interactions with state and local governments, and Service to the Citizen. EMTF is currently supporting several e-mail pilot projects to promote government e-mail.

Throughout the Department of Commerce, Electronic Commerce applications are being implemented. For example, the Bureau of Export Administration processes export licenses electronically; the Economics and Statistics Administration maintains the Department's Economic Bulletin Board; the National Oceanic and Atmospheric Administration electronically disseminates weather information to local meteorologists and news stations; the Office of the Secretary receives and processes Federal Express invoices using EDI; and the Department transmits time and attendance data to the U.S. Department of Agriculture National Finance Center electronically. Many more initiatives are either underway or planned.

Also within the Department of Commerce, the National Institute of Standards and Technology (NIST) has been active in R&D for Electronic Commerce as well as efforts to increase public dialogue on Electronic Commerce and standards issues. NIST assists the private sector with the development of the technical underpinnings for interoperability, and also works to coordinate and facilitate the standards process. NIST has issued Federal Information Processing Standard 161, which assures federal agency adoption of appropriate national and international voluntary standards for use in Electronic Commerce. NIST reports on Electronic Commerce include: "National Public Key Infrastructure Implementation," "The Federal Certificate Authority Liability & Policy," "Good Security Practices for Electronic Commerce, Including Electronic Data Interchange," and "Analyzing Electronic Commerce." NIST's work to establish the Digital Signature Standard (DSS) is critical to the success of Electronic Commerce. Other NIST activities include the establishment of an Electronic Commerce Integration Facility (ECIF), described below:

> The goals of the ECIF are: (1) to serve as a technology transfer center to assist government and industry in the deployment of Electronic Commerce applications; (2) to demonstrate, through prototypes and pilots, generic open systems implementations of Electronic Commerce applications; (3) to perform, in cooperation with industry, research, development, and testing of Electronic Commerce applications and infrastructure services. These goals should

assist in the removal of barriers that are currently preventing the transition from paper-based commerce to Electronic Commerce, and should help to advance technology in order to permit the development of future Electronic Commerce applications.

The ECIF is developing a pilot electronic procurement system which will assist agencies in the implementation of the Executive Memorandum on electronic procurement. Other Electronic Commerce applications, such as health care and manufacturing, will be addressed in the future. Prototypes and pilots of infrastructure services, required by Electronic Commerce applications, are also under development. The initial services included are: secure electronic mail, directories, EDI translation and transmission, and Remote Database Access.

Other ECIF deliverables will include: (1) guideline documents disseminating the knowledge gained from the facility, (2) liaison services with other government and industry groups involved in Electronic Commerce, and (3) consulting services, which help users in the federal and private sectors deploy Electronic Commerce applications.

The Security and Exchange Commission's (SEC's) EDGAR system is designed to automate the receipt, processing, and dissemination of documents filed with the SEC. The purpose of EDGAR is to increase the efficiency and fairness of the securities markets for the benefit of investors, corporations, and the economy by accelerating the processing, dissemination, and analysis of time-sensitive corporate information filed with the SEC. Under the fully implemented EDGAR system, millions of pages of information currently submitted to the SEC on paper will be transmitted and stored electronically using electronic communication and data management systems. Currently, 3,400 of the approximately 15,000 U.S. corporations with filing obligations are using the system to submit 309 different filing types. Once the electronic filing is accepted, public information is immediately disseminated and becomes available quickly to investors, the media, and others on computer screens via the SEC's public reference rooms and through electronic subscription services provided by information resellers. EDGAR makes disclosure information readily available on both a document retrieval and a text search basis to all of the SEC operating divisions and offices.

The Department of Veterans Affairs (VA) is using EDI as a business reengineering tool to improve relationships with third parties regarding benefits delivery, seeking to improve the quality and reduce the costs of doing business. VA has recently completed a Business Case Analysis that outlines savings of approximately $500 million over a five year period by replacing approximately 15 commonly used business documents, including purchase orders, invoices, health care claims and others with their electronic equivalents. VA is currently developing an implementation plan for Electronic Commerce applications.

The Department of Defense Continuous Acquisition and Life-Cycle Support (CALS) Initiative is an industry and government strategy to enable more effective generation, exchange, management, and use of digital data supporting the life cycle of a product through the use of international standards, business process change, and advanced technology application. The CALS initiative was started in September 1985 by the U.S. Department of Defense with the goal of enabling the integration of enterprises on a worldwide basis through the development, implementation, and integration of digital information standards for product design, manufacture, and support. The vision is for all parts of a single enterprise to be able to work from a common digital database, in real-time, on the design, development, manufacturing, distribution, and servicing of products.

The Tennessee Valley Authority (TVA) is modernizing business processes to allow TVA to compete more effectively in today's global economy. A critical tool in this modernization process is the NII. TVA is streamlining its procurement processes to use electronic data interchange to solicit bids, develop contracts, and to deliver and receive products. As a result of this initiative, TVA has developed electronic data interchange relationships with 56 preferred suppliers. Of the 56 suppliers, 19 are small, minority, or woman-owned businesses.

The U.S. Postal Service (USPS) has instituted a Postal Electronic Commerce Services project at the request of the Department of Defense to provide trusted third-party value-added services

for Electronic Commerce transactions. The services consist of a registration authority service for individuals to obtain a public-key certificate to sign electronic transactions, a time/date stamp service to prove existence of an electronic record and to seal it to prevent undetectable alteration and a directory service for identification and location of Electronic Commerce trading parties. The services, developed jointly with NASA, will be tested with the Federal Aviation Administration and the Internal Revenue Service. A decision will then be made by the USPS concerning making the services generally available throughout government. The USPS is also working with other federal agencies, most noticeably the Social Security Administration, the Internal Revenue Service, and the Department of Veterans Affairs, to establish a generic government-wide Service to the Citizen kiosk program. The program will provide an economy of scale and a "one stop shopping" kiosk program for the public. The kiosk program material will migrate to interactive TV delivery of the government information services at such time as the NII supports secure home interactive TV services.

The Internal Revenue Service, which introduced an Electronic Filing System on a limited basis in 1986, received over 13 million individual returns from over 75,000 filers last year, a number that is expected to grow to 80 million returns within the next 10 years. Over the past few years the system has expanded to include certain business forms and balance due returns. In 1991 a Federal/State cooperative program was started that has grown to include more than 25 states. In 1992 a 1040EZ file-from-home pilot (TeleFile) was introduced via touch-tone phone. The current system uses a proprietary input format but a pilot is scheduled to accept American National Standards Institute/American Standards Committee X12 (ANSI/ASC X12) EDI input in the near future.

Private Sector Activities

Many private sector organizations are developing and implementing Electronic Commerce applications for the NII; indeed, the Gartner Group has made a strategic planning assumption that by 1997 there is an 80 percent probability that electronic messaging will become more important for Electronic Commerce than EDI [Gartner Group ECS Research Notes, February 14, 1994]. Evidence of this movement is that the Electronic Messaging Association, the national U.S. e-mail association, has created an Electronic Commerce Committee to promote adoption of Electronic Commerce throughout the U.S. and internationally. National voluntary standards organizations working in electronic data interchange, in bar coding, and in electronic exchange of product modeling and specification data, are providing necessary components for the infrastructure. Below is a brief list of examples of current private sector activities:

CommerceNet

CommerceNet is an $8 million project designed to help Silicon Valley businesses make commercial use of the NII. Half of the funds for CommerceNet will be provided by a federal "Technology Reinvestment Program" (TRP) grant. Matching funds will be provided by the State of California and participating companies. CommerceNet's goal is to make public computer networks, such as the Internet, "industrial strength" for business use. CommerceNet will address issues including low-cost, high-speed Internet access using newly deployed technology such as Integrated Services Digital Network (ISDN) services and multimedia software. CommerceNet will support a range of commercial network applications such as on-line catalogs, product data exchange, and engineering collaboration. It will also offer outreach services such as technical assistance to small- and medium-size businesses that want to access public networks. The CommerceNet consortium is sponsored by Smart Valley, Inc., and the State of California's Trade and Commerce Agency. Enterprise Integration Technologies, a local high-tech company specializing in Electronic Commerce, will lead the effort.

Enterprise Integration Network (EINet)

The Microelectronics & Computer Technology Corporation (MCC) is an industry consortium of more than 80 leading companies in the microelectronics and computer industry committed to the joint development of pre-competitive technologies. MCC has developed the Electronic Integration Network (EINet) which dramatically reduces the time and costs involved in getting products and services to market using Electronic Commerce technologies. EINet allows the wide-

spread, secure exchange of information and services in order to increase and enhance business activity across networks. With ElNet, businesses and organizations are able to interconnect with partners, suppliers, and customers. Four initial services – directory, security, remittance, and advanced e-mail – have been developed based on industry priorities. The Advanced Research Projects Agency, the National Institute of Standards and Technology, Electric Power Research Institute, Sematech, and the National Center for Manufacturing Sciences, among others, are participating in the ElNet program. Pilots are being planned in the manufacturing, health care, and general commerce arenas. Geographically based initiatives are also developing in Albuquerque, Austin, Omaha, and Rochester. These initiatives are aimed at increasing the economic viability of a specific region.

Electronic Manifest Bar Code (EMBARC)

The publishing industry has been using EDI since 1985 and has grown its Electronic Commerce uses through an evolution of progressive changes that started with financial or operational justification and that have evolved into strategic service differences. The publishing industry has developed a proprietary set of EDI transactions and bar codes called Electronic Manifest Bar Code (EMBARC) which it uses to used to track and control paper shipments. This standard is expected to migrate to X12 EDI standards in the near future. As an example of the benefits of EMBARC, Judd's, a Virginia printer, has used the EMBARC technology to reduce on-hand paper stock from 100 to 25 days and reduce their inventory by $3 million. EDI transactions are also used to provide activity reports electronically to such customers as *Newsweek* in an automated process that is quicker and more accurate and that saves time.

Production Order Specification (PROSE)

Using a new complex EDI transaction for Production Order Specification (PROSE), also to be converted to X12, New York based printer World Color Press receives detail printing instructions that can set up a print job 60 percent faster and can be used by the U.S. Postal Service to rate the resultant mail pieces. Use of PROSE enables customers such as *U.S. News & World Reports* to make last minute changes while extending their deadlines closer to print time. PROSE in the future will be used to customize printing for companies, regions, or even individuals to receive their personal customized copy of their national magazine!! What started with notices and control of paper shipment, through successive iterations, will generate whole new strategic products and capabilities [*EDI News*, pp. 1–3, "Publishing Industry Gets The Word Out On EDI", January 10, 1994].

Financial Services Technology Consortium

The Financial Services Technology Consortium (FSTC) is a consortium of financial service providers, national laboratories, universities, and government agencies whose goal is to enhance the competitiveness of the U.S. financial services industry. The FSTC sponsors interbank technical projects with particular emphasis on projects involving the NII and the High Performance Computing and Communications Program such as Electronic Commerce/consumer payments; fraud prevention and control; and trusted, secure remote access to financial services.

In addition to the examples cited above, the Council on Competitiveness has created an inventory of Electronic Commerce applications in various stages of development. Their inventory includes:

> "Institute for a Distributed Workplace" and "Intell-I-Center" are two Electric Power Research Institute (EPRI) projects designed to study the impacts of telecommuting on productivity and social structure.
>
> "Internet Mercantile Protocol" is a Bellcore proposal to develop technologies that will permit Internet users to conduct business over Internet, and use Internet services to validate and complete the transaction.
>
> "Kodak Picture Exchange" is a Kodak pilot to demonstrate an on-line marketing service for the commerce of images and the commerce of image-dependent products or services. Kodak's project enables keyword and visual searching of an image database, transmission of thumbnail images to the desktop, and electronic ordering.
>
> "Interactive Transaction Partners" is an operational joint venture among General Motors/Electronic Data Systems (GM/EDS),

US West and France Telecom to provide interactive financial and information transactions to the consumer and small business in the home and office. It provides a platform to move seamlessly among applications.

"PowerView (Energy)" is an operational EPRI pilot that provides residential and other electric customers the ability to manage their electricity to reduce their energy expenses. PowerView is a combination of software and broadband network technology that allows real-time information exchange between the utility and its customers. It has ample capacity to integrate other services to the home, such as video and telephone.

"Workers Compensation Reporting Services" is an EDS developed system that conveys an employer's First Report of Injury to the state and to the insurance agent, carrier third party payor, or self-insurer and to the state's Industrial Accident Board.

International Activities

The United Nations Economic Commission for Europe is developing an international family of standards called UN/EDIFACT that is starting to make possible world-wide Electronic Commerce. Many nations throughout the world, including the United States, contribute to development of these standards.[8]

The United Nations has established a Commission on International Trade Law (UNCITRL) to develop rules for the international adoption of EDI. The United Nations Commission on Trade and Development (UNCATD) is working on reducing the administrative costs of conducting international trade, which currently is $400 billion annually, to enable $4 trillion of commerce. UNCTAD is holding a World Symposium on Trade Efficiency in Columbus, Ohio, on October 17-24, 1994. Secretary Ronald H. Brown, of the U.S. Department of Commerce, will serve as host and UN Secretary-General Boutros Boutros-Ghali is expected to attend. Columbus, one of the fastest growing centers in North America for international trade and utilization of information technologies, has been named The North American Trade Point by UNCTAD under its Trade Efficiency Initiative Project. This project is an effort to include the developing world in Electronic Commerce with the developed world.

The European Community started in 1988 a Trade EDI Systems (TEDIS) program to educate users, to help set standards, and to help implement and coordinate EDI systems in such industries as automotive, chemical, and retail.

Singapore perhaps is the leader in the world today in its adoption of Electronic Commerce. Singapore has adopted a national program to aggressively maximize its use of telecommunications and paperless processing to establish competitive advantage for its nation. Singapore represents a potential national model and benchmark for Electronic Commerce.

Worldwide recognition of the potential payoff for international enterprise integration is evidenced by CALS organizations in Australia, Canada, France, Germany, Italy, Sweden, Denmark, Norway, Netherlands, Japan, and Taiwan. Singapore and South Korea are also considering CALS efforts.

PART III: Where Do We Want to Be?

The ultimate goal of the NII in Electronic Commerce is the creation of a national electronic marketplace which is secure, open, affordable, easy to access, and easy to use. The exponential growth of the Internet indicates that connectivity and the use of electronic mail, bulletin boards, and file transfers are growing at an enormous rate. In addition, EDI is currently being used by many individuals and organizations to automate simple business decisions and financial transactions. To make an advanced NII for Electronic Commerce a reality, individuals and organizations must continue to increase their use of and familiarity with networked communications services and tools, such as the Internet and EDI, as quickly as makes financial sense.

A fully scaled, comprehensive national Electronic Commerce capability, however, involves much more than the reduction of paperwork and the speeding of decision making information for business and government transactions. In particular, the creation of an advanced infrastructure

[8] ANSI/ASC x12 has agreed to adopt EDIFACT standards, and has established the EDIFACT Alignment Task Group.

that can support national Electronic Commerce requires solutions to many technical, legal, security, financial, and regulatory barriers, as well as the widespread adoption and use of a variety of technical standards for communications, information processing, and security.

Although the federal government itself generates a small portion of total commerce, it may be, with its Departments of Defense, Veterans Affairs, and General Services Administration leading the way, the largest single purchaser of goods and services in the United States. All over the government, agencies are beginning to adopt Electronic Commerce for the very high volumes of information interchanges required in its tax, insurance, and regulatory activities. Implementation of Electronic Commerce by the federal government, including its adoption of applicable national voluntary standards, has provided and will continue to provide significant momentum towards implementation nationwide. As a result, the full implementation of the President's memorandum on Electronic Commerce is an important goal.

While the government as a large user of Electronic Commerce can provide leadership, it is the private sector that generates the overwhelming majority of commercial transactions, and therefore will make an overwhelming majority of the investments in Electronic Commerce capabilities. As such, for an advanced NII to develop and succeed, it is critical that the private sector own and operate it. The nature of Electronic Commerce, in particular the fact that cooperation and flexibility among permanent and transient partners as well as the establishment of standards for the interoperability of communications networks, information and data exchange, and security services are needed means that the government can play a pivotal role in creating the NII by facilitating and coordinating private sector efforts.

Until many technologies, Electronic Commerce capabilities, and security provisions are proven, individuals and companies will be hesitant to invest in research, development, and implementation of Electronic Commerce applications. For example, concerns about threats to proprietary data, computer virus exposure, unauthorized access, increased single points of failure, control and auditing functions, and search and verification mechanisms inhibit investment.

Many of these concerns go beyond Electronic Commerce; in particular, information protection, privacy, and security have been identified as a critical requirement and enabler in each application strategy paper. It is a cross-cutting need and the challenge for government and industry is establishing a comprehensive and coherent approach for these applications. This will require leadership and cooperation across government and industry, and the requirements for Electronic Commerce will offer a benchmark application.

The President's efforts toward "Streamlining Procurement Through Electronic Commerce" afford the government a unique opportunity to provide the needed leadership and to demonstrate secure and trustworthy operational solutions. Consistent with the National Performance Review (NPR) Recommendations, the Government Information Technology Services (GITS) Working Group must provide the leadership to identify the steps that must be taken to provide solutions that cross-cut applications in an integrated fashion. With such leadership stovepipe systems can be avoided, and the benefits of an integrated and comprehensive solution fully realized.

The documentation of success stories and the development of a national scorecard and metrics for evaluating Electronic Commerce implementations as well as the development of legal and regulatory structures that address these threats will help ameliorate some fears. In addition, the expansion of national R&D, pilot demonstrations, and testbeds, and the continued support of the High Performance Computing and Communications Program and other long-range, high risk R&D programs will further reduce fears and create a healthy environment for investment in Electronic Commerce applications.

To create a national commerce infrastructure, the following seven subject areas, illustrated in Figure 1 (see below), must be coordinated and facilitated through public-private sector partnerships, setting base implementations and standards for minimizing costs overall, but allowing for flexibility to meet unique requirements:[9]

[9] Saltman, pp. 52-62.

- Agreements among organizations of partners interchanging diverse subject matter, so that the developed infrastructure meets all requirements in a cost-effective manner;
- Details of message interchange standards, i.e., character sets, data types, data elements, message syntax, message types, and provision for inclusion of security parameters;
- Supporting interchange technologies, such as communications protocols, audit trails, security, and graphics interchange capability;
- Network reliability, availability, and management, including agreements among connecting networks, to assure that messages are delivered in a timely manner with integrity, security, and appropriate audit trails;
- Directories of prospective partner information, including network addresses and representational data, such as contacts for Electronic Commerce, banking arrangements and financial terms for buying and selling, and sources for security credentials and public keys;
- Technology and standards development, including a national Electronic Commerce architecture employing a distributed implementation using networks such as the Internet that tie together other networks, and transmit electronic mail, formatted commercial documents and graphics.
- Legal and regulatory framework, including strategies for facilitating the transition from paper-based commerce to Electronic Commerce, and for addressing such issues as legal acceptance of electronic documents and electronic signatures, assurance of the "trustworthy" electronic record and the "trusted third party."

PART IV: How Are We Going to Get There?

It is probable that Electronic Commerce, like fax, will grow slowly until a critical mass is reached, and then explode in popularity. How can we reach critical mass as quickly as possible while ensuring that the transition from traditional commerce activities to Electronic Commerce activities is as smooth as possible? The following paragraphs represent only a starting point for

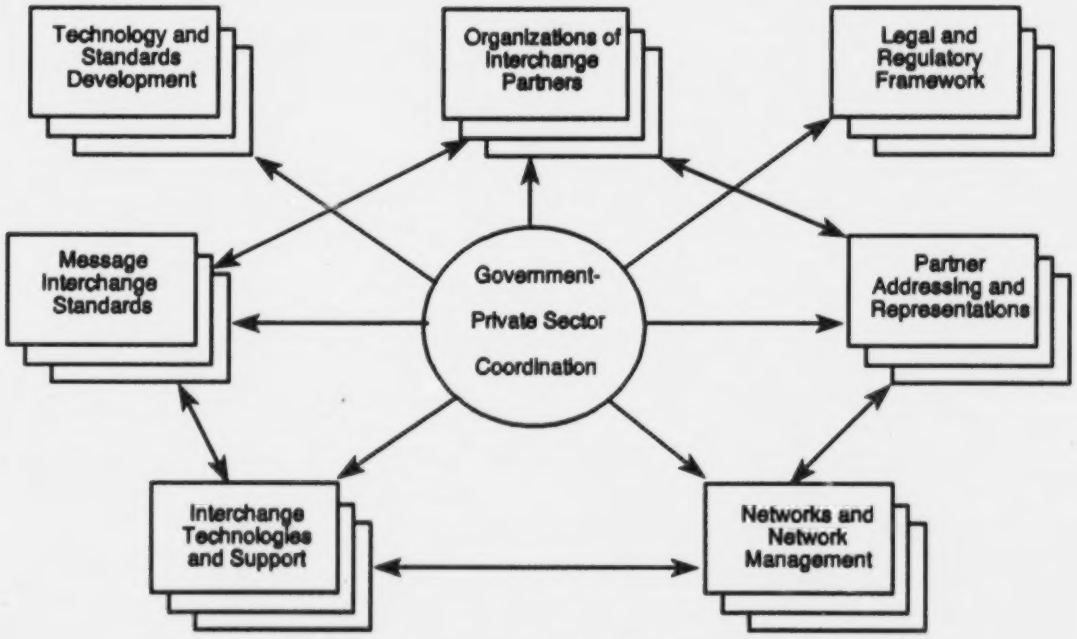

Figure 1. Planning for Global Electronic Commerce.

formulating the key issues and questions, and for initiating the key actions and policies that are needed to facilitate the development of the Electronic Commerce application as part of the NII. The full range of issues described in this paper must be addressed to realize the full potential of Electronic Commerce.

Issues and Questions to be Addressed

- Government and industry cannot accept Electronic Commerce unless electronic transactions are secure. There are clear requirements for authentication of the source of a transaction, verification of the integrity of the transaction, prevention of disclosure of the transaction to unauthorized users, and verification of receipt of the transaction by the intended trading partner. Is the current work in computer security services adequate for timely resolution of these technical issues, or should the direction of work be changed or the level of effort increased? What organizations and mechanisms are needed to ensure that government and industry can jointly address security-related issues?
- Electronic Commerce application will require the interoperation of communications, data management, and security services. These services will be provided by many different companies, including Value-Added-Networks, systems integrators, hardware vendors, and software vendors. Given this diversity, how can government and industry ensure that Electronic Commerce will be reliable, and that the components can be assembled, maintained, and upgraded at reasonable cost? We must develop technologies, measurement tools, testing services, interoperability demonstrations, etc., to ensure that components satisfy the current and future requirements of government and industry. Should the NIST Electronic Commerce Integration Facility be tasked to lead this effort? What other organizations can lead or contribute to this effort? What actions are needed to ensure appropriate funding?
- Successful resolution of technical issues will be insufficient to ensure the widespread use of Electronic Commerce; economic, cultural, regulatory, and legal barriers to Electronic Commerce must be identified and removed. For example, how can government and industry ensure that Electronic Commerce will be viewed positively by workers? What incentives can be provided so that workers will share in the benefits of Electronic Commerce? How can government and industry establish realistic business cases and success stories to encourage potential users and providers of Electronic Commerce hardware, software, and services? Are the benefits discussed in this paper adequate, or are additional incentives required? Should government and industry create a joint task force to identify the most critical barriers and incentives and identify or create appropriate organizations to remove those barriers and provide those incentives. What actions are needed to ensure appropriate funding for the joint task force and for the organizations that it will identify or create?

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Health Care and the NII

DRAFT FOR PUBLIC COMMENT

PART I: What Is the Application Arena?

Description of a Health Care Information Infrastructure

Implementation of wide-area, comprehensive, integrated, networked information systems is a logical response to the challenges faced by the Nation's health care delivery system. These challenges arise from several sources: dissatisfaction over rising health expenditures, in both private and public health care programs; concern over the personal health security issues of access and continuity of insurance coverage, and serious questions about the uneven quality and appropriateness of health care [1,2]. These challenges are driving the health system to a cost-conscious, competitive, market-based, managed care environment. In such an environment, information systems linked to the National Information Infrastructure (NII) are destined to play a central role.

The applications of the NII have significant potential for cutting unnecessary medical costs and improving health care access and quality. With the NII in place, consumers, physicians, other practitioners, hospitals, payers, and managers could readily obtain the information needed to make informed choices about treatments, providers, institutions, and health plans. With standards for defining, collecting, communicating, and storing administrative and clinical patient care data, scientific studies could point the way to medically effective and cost-effective care. National networks would enable all persons and health care providers to access the most recent information about particular medical technologies, clinical treatments, and provider performance. Patient outcome information could be linked to medical treatment data in a variety of settings so that all interested parties could obtain a better understanding of what works in the practice of medicine in the community and where it works best.

In addition to improving clinical processes, the NII can simplify and speed up administrative processes within the health system, eliminating much duplication of paperwork and making uniform the data definitions required to make health care claims. As a result, electronic claims and payment transfers could occur rapidly over national networks and administrative costs would be significantly lowered. However, there is much infrastructure to build.

A Vision of the Future

SCENARIO 1: In a rural area, a child awakens with severe coughing, fever, and a rash on her chest. Her mother dials the interactive telecommunication connection to access medical care support and describes her child. The nurse at the other end asks for the mother to connect special probes that monitor the child's temperature, blood pressure, pulse. She then listens through an electronic stethoscope to the child's breathing. She examines the rash through the high resolution telecommunications viewer. After consulting information through the NII about recent health events reported in the community, such as the incidence of measles, bacterial and viral infections, she recommends action to the

mother. Such action could be (1) stay on the connection and the physician will be right with her, (2) remain at home and continue to monitor the child and report in, (3) come in for an appointment with the doctor, or (4) head immediately to a designated emergency room. A valid medical encounter record is documented by this system and sent to the family's longitudinal medical service file, to the community's information repository, to the family for verification, and then to the family's health plan for payment.

SCENARIO 2: A state public health official examines the state's health profile based on encounter records (with the identifiers removed) from health plans serving the state's communities. The records are retrieved from a statewide information network which is part of the NII. She is alerted by the information system to a statistically significant high incidence of children treated for respiratory disorders in a community. This leads her to call up the laboratory information from a sample of these children (the identifiers are removed but the information has been linked). In one of the cases, the laboratory results confirmed a diagnosis of whooping cough (pertussis). Immediately, she queries the immunization records and finds that some children do not appear to have been vaccinated. She then calls the community's health department to verify the data in the system. Finding it accurate, she queries the information system about the vaccine inventory in that community and, discovering it to be short of pertussis vaccine, calls four other communities with ample supplies to request that half of their vaccine be shipped to the first community. After notifying the first community of her actions and receiving their plan to resolve the problem, she returns to her examination of the state's health profile.

SCENARIO 3: In the hospital of a major medical university in the state, Dr. Jones visits a virtual reality learning center to review procedures for a surgical removal of a portion of the prostate (prostatectomy). As she sits in the virtual reality clinical education room, she takes the electronic scalpel and feels the sensation of cutting into the patient, the texture of the skin, the hardness of the prostate as she is guided to making the proper incisions. The simulation program that guides her uses an electronic model human object obtained via the NII from a national library of reference models in conjunction with clinical measurement readings from the actual patient who will undergo the prostatectomy. Two floors up, Dr. Smith is performing a cataract surgery operation using robotics assistance. Although Dr. Smith is past middle age and has slight tremors in his hands, the robotics device with microsurgical vision enhancements eliminates the effects of his tremors. This supporting device allows his surgical productivity to continue for many years, increasing the life-long value of his medical training and years of experience.

A Picture of Today

Other sectors of the U.S. economy, some even less data- and information-intensive than the health sector, have for many years centered their operations around computerized systems. Banks, airlines, stock markets, and even salvage yards use computers to communicate, maintain inventory control, allocate costs, bill, and manage their major activities in an integrated, seamless manner. All these industries have experienced operating efficiencies, improved products and services, and, most important, greater customer satisfaction.

These same benefits can be acquired for health care. The health sector, however, has lagged far behind the other sectors of our economy in applying information and communication technologies. Most hospitals and clinics have computers but relegate them to perform isolated, relatively small segments of the organizations' clinical operations. In these settings, the computer's widest use is for billing purposes and for patient admission, discharge and transfer functions, not for clinical purposes. Few hospitals and clinics link all caregivers together over local- or wide-area networks.

As a result, patient care information is re-entered numerous times, information of value is not widely shared, and the paper outputs of these systems are manually collated in what is called a patient record. In this paper form, the patient

record does not provide the basis for efficient clinical management, quality control, cost allocation, accurate billing, or clinical or health services research. Often the paper record and the information it contains is simply not available to the clinician when needed. The course of the patient through the health system is obscured by lack of documentation of the decisions, consultations, and sequence of interventions that he (or she) experiences. Thus, it is difficult to trace longitudinally the course of an individual patient, impossible to aggregate the data across a large number of similar patients, and improbable that all useful medical knowledge can be gleaned from the ongoing treatment of patients. Without reliable, comparative, performance feedback to the provider of health care, it is not likely that improvements in the quality of care or the efficiency of operation can be effected. Reliable feedback requires uniform vocabulary and coding standards for health care conditions, diagnoses, and procedures. Further, without an active communications interface among providers of care, it is difficult to make available—especially in underserved urban and rural areas—the benefit of the rapidly developing and evolving body of knowledge arising from biomedical and health services research.

What is the Public Interest in Promoting the Application?

Health care spending is high and growing.

In 1994, the American public will spend $1 trillion on health care, nearly 15 percent of its Gross Domestic Product (GDP). National health care expenditures have risen by 10.5 percent per year for the past 8 years—more than double the rate of increase in the consumer price index [3].

Insufficient knowledge exists for informed decision making.

Health and medical decision-making processes are flawed by a lack of knowledge and by financial considerations. The man (or woman) on the street has less knowledge about medical treatment alternatives for a specific condition than he (or she) has about any other service he buys. Therefore, he is more heavily dependent upon experts in the health care industry who often have no financial incentive to refrain from ordering every service, regardless of cost, if there is the hope of a benefit, however small.

People do not pay the full price of the health care they consume.

There would be no problem with the rapid rate of growth of national health expenditures and its portion of the GDP if it adequately represented consumer preferences expressed in the marketplace. After all, how much would the GDP have grown if not for the large increases in national health expenditures? Growth by itself is not bad. There is more than a suspicion, however, that when people pay 25 percent or less out of pocket for medical care at the time of choice, with insurance or public coffers paying the rest of the cost, there is a tendency to consume additional medical services. The value to the consumer of many of these additional services is less than the cost of the resources to produce them.

How Can the NII Help?

While the NII cannot change the U.S. health care system's financial incentives directly, it can support research into cost containment efforts and payment initiatives targeted at incentives to lower costs. For example, it could supply information to help appraise which payment systems in use are the most cost-effective.

Further, the NII can provide information that increases knowledge about the medical effectiveness of alternative treatments and make it available to the providers and consumers of health care. The NII also can make available information consumers need to become more cost-conscious purchasers of health care services. The NII can provide an infrastructure that supports personal health improvement and medical technology assessment.

Finally, the United States is one of the world's leading manufacturers of medical technology. With increased emphasis on cost-effective technology, there is a greater need for information about how well alternative technologies work when applied (1) in an ideal setting such as an academic medical center and (2) in the average community.

The goal is to generate knowledge about which treatments and technologies work best for specific clinical conditions and under what circumstances, to have this knowledge available at the point of service (care), and to have medical

decisions made jointly by caregivers and their patients. The NII can help attain this goal by supporting the analysis of large quantities of patient care and administrative data, by protecting its confidentiality, by assisting in the dissemination of information based on these data, and by adding value through the evaluation of the information gained from these data and converting it into useful knowledge.

It is well recognized that there is substantial unexplained geographical variation in medical practices. The findings of unexplained differences in decisions about the best treatment for similar patients with the same condition elevates concern about the quality of care being delivered. Analyzing of patient care data from communities and providing feedback about these findings to the caregivers and consumers can both reduce inappropriate care and increase beneficial care. It can also improve continuous, life-long learning for health care providers who have difficulty keeping up with the flood of biomedical literature and clinical practice guidelines.

By providing information access at home, schools, and the workplace, the NII can play an important role in improving public knowledge and decisionmaking about health, thereby reducing the significant information gap between consumers and clinicians and improving clinical outcomes. National and community networks that allow consumers to obtain information about their own health care conditions and to obtain professional medical advice in their homes can empower patients to take better care of themselves.

What is the Evidence of the Benefits?

Although the health care industry has been slow to adopt information and communication technologies in routine patient care, there are studies pointing to where the greatest benefits may be achieved. However, because these studies most often are conducted in single sites, both the size of the benefits to be achieved in multi-site and community settings and the costs of obtaining these benefits are unknown. Some examples of the studies follow:

- In randomized controlled trials conducted at Wishard Memorial Hospital in Indianapolis by the Regenstrief Institute for Health Care at Indiana University, experimental groups of attending physicians that wrote their orders on microcomputer workstations were shown (1) prior test results for their patients, (2) computer predictions of abnormal results if another test was ordered, and (3) test prices at the time test orders were placed. These three trials showed reductions in outpatient test-ordering costs. A further randomized controlled trial tested the effect of physicians writing all their inpatient orders on workstations with screen information that encouraged cost-effective ordering. This intervention resulted in charges per admission reduced by $887 and hospital stays shortened by .89 days. However, achieving these savings did require more physician time per patient (33 minutes more over a 10-hour observation period, or 5.5 minutes per patient). [4]
- Including the costs, as well as the benefits, of implementing electronic data interchange for administrative health care activities (such as consumer enrollment, eligibility checking, billing, and claims payment), the Workgroup for Electronic Data Interchange (WEDI) believes "the cumulative net savings over the next six years (to the year 2000) is estimated to total over $42 billion." [5]
- An Automated Antibiotic Consultant software program was introduced into the HELP (Health Evaluation through Logical Processing) system at Latter Day Saints Hospital in Salt Lake City and evaluated. The Consultant was used when it was necessary to select an antibiotic therapy before the results of bacterial culture and susceptibility were known. The Automated Consultant suggested an appropriate antibiotic 94 percent of the time. The Consultant can support improved physicians' decisions under such conditions of uncertainty whether accessed on site or through a medical network. [6]
- The HELP system was also instrumental in determining the optimal timing (0 to 2 hours) of antibiotics before surgery to minimize the risk of post-surgical infection. The uniformity of data produced by such systems is advantageous not only for obtaining accurate patient care data, but also for conducting medical effectiveness studies. [7]

- A case study supported by the U.S. Public Health Service's Agency for Health Care Policy and Research (AHCPR) of a comprehensive hospital information system in one hospital in California, compared with systems in two other hospitals, was recently completed. The original system was installed in 1975. Now, almost 20 years later, the hospital continues to outperform comparison hospitals in all financial indicators. It experiences shorter patient stays (adjusted for case mix) and lower costs per admission. [8]
- A National Cancer Institute cancer treatment information system, Physician Data Query (PDQ), provides physicians and patients with information about state-of-the-art therapy and clinical treatment trials for each cancer and its stages. In PDQ, new literature and cancer prevention and treatment trials are continually reviewed by panels of clinical cancer experts, synthesized monthly, and updated. PDQ has experienced rapidly increasing use since its implementation and provides necessary information about the most recent cancer treatments and research findings worldwide using CancerFax® and CancerNet™.
- The Comprehensive Health Enhancement Support System (CHESS) developed at the University of Wisconsin runs on a personal computer and offers a range of information, social and emotional support, and problem-solving tools for people in health crises. CHESS is typically placed in homes, but can also be installed in health care settings and community sites. CHESS currently offers modules for early stage breast cancer, HIV/AIDS, sexual assault, academic failure, adult children of alcoholics, and stress management. Such personal health information systems may grow to achieve user familiarity and acceptance, heavy use, quality of life improvements, and reductions in total costs of care.

PART II: Where Are We Now?

In many health care settings, patient information is handwritten in paper records and stored manually. Some of this is due to "state quill pen laws" that require handwritten pen and ink signatures on paper medical records. The current health information system does not adequately support patient care, medical effectiveness and cost effectiveness, and the public health of the community. This lack of support is often a result of incompletely recording the patient's signs, symptoms, and conditions; coding the patient's medical diagnoses to maximize billed charges instead of accurately describing the patient's ailment and the treatment given; and storing this information in ways that hinder both retrieval and making comparisons among patients with similar complaints.

Consumers have insufficient information to make informed choices among the health insurance plans, health institutions, and providers available to them. Providers of care have insufficient means to keep abreast of all the information generated in their fields of specialty. Moreover, they often are unable to marshall all relevant information on a patient when making medical decisions. Health organization administrators are hampered in their ability to merge administrative and clinical information to make rational choices concerning resource allocations, quality of care, and product and service pricing. Payors of care have insufficient information to determine what package of benefits by which providers of care yield the best value for their clients.

Further, public health officials should have the ability to more rapidly detect sharp increases in the incidence of influenza, specific bacterial infections, and other public health problems and to act quickly in health crises to inform the community. Public health policymakers often have insufficient information for offering solutions to health care problems. As a result, public health decisions are made without the advantage of timely, relevant information using technology that could reduce the costs of health care and improve patient outcomes and the health status of populations.

The value of data on patient treatment and outcomes – especially automated, uniformly defined, linked, and anonymously aggregated data – is increasingly recognized and demanded throughout the health care sector. These data are needed for clinical, quality assurance, utilization review, business planning, administrative, and public health purposes. For example, computerized ambulatory patient care data are scarce and not uniform in definition, coding, or content. Computerized hospital clinical care data

are collected on hospitalized patients in a small number of settings, but often are not stored for long in retrievable form after the patient is discharged.

As valid methods for assessing the quality of care increase, so will the value of community patient care data. When the benefits from this information are shown to exceed the costs of producing it, society must find a way to pay for the resources necessary to produce it.

Confidentiality and privacy are important concerns. Society must deal with perhaps its most vital information issue: assuring the privacy, confidentiality, and security of health care data about identifiable individuals. Even though patient care data can lead to important information for health care providers and their patients, it also has potential for personal harm if disclosed inappropriately.

For example, these data may be required for emergency medical treatment or telemedicine applications in rural areas. As the data are transferred across wide areas, the system that transfers it must provide security against unauthorized access and disclosure, maintain the integrity of the data, and confirm the originators and requesters of the data. Quite possibly, most of the uses of patient care data may not require that the individuals be identified. When patient identification is necessary, the legal system must provide severe penalties for inappropriate uses of confidential patient care data. Although many States have their own privacy laws, many others do not. Moreover, uses of patient care data are not controlled uniformly from State to State. This problem must be addressed by national legislation.

Selected Private Activities

Private-sector activities discussed here include coordinated activities and projects in standards development, computer-based patient records, telemedicine, and community health data repositories.

Standards. In the private sector of the United States, the development of medical information standards is coordinated through the American National Standards Institute (ANSI) Healthcare Informatics Standards Planning Panel (HISPP). AHCPR, in cooperation with the Food and Drug Administration, supports the meetings and administration of HISPP. The HISPP is also the official link between U.S. and European standards developing organizations. Other countries (particularly the European countries) are making notable progress with central development of medical information standards. Pursuing international cooperation in the development of these standards could prove beneficial for standards development in the United States.

Administrative health data standards are being developed by the ANSI-accredited standards committee X12, through its subcommittee X12N. The Workgroup for Electronic Data Interchange is a private sector advisory body that has provided much leadership for these standards, which are essential for electronic exchange of health insurance business information. Progress has been faster for administrative health data standards than for clinical health data standards.

The development of standards for the electronic interchange of clinical data is becoming more coordinated under the Message Standards Developers Subcommittee of ANSI HISPP. These standards will permit standardized data flows among departments of a hospital, for example, and among hospitals, physicians, and other medical organization entities. Some examples of standards for the coding of medical diagnosis and procedures are the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) and Current Procedure Terminology, 4th Revision (CPT-4). The ICD-9 coding system was developed by the World Health Organization and modified in the United States by the Health Care Financing Administration and the National Center for Health Statistics to produce the ICD-9-CM. The American Medical Association maintains the CPT-4 coding system. These codes, however, are used more for billing purposes than for their clinical information. They do not code the signs, symptoms, and conditions of the patient upon which the diagnosis is made.

The Systemized Nomenclature of Medicine (SNOMED), 3rd Edition, does code for signs and symptoms of diseases as well as for disturbances in biochemical and enzyme factors of interest to the clinical pathologist and for anatomy, pathology, and etiology upon which the diagnosis is made. However, clinical codes

that better reflect the conditions of the patient and the treatment received are needed. Further, much work is needed to develop standard validated measures of the patient outcomes of medical care. Although coordination of standard development efforts continues to improve, the pace of clinical data standards development has much room for improvement, and there are many gaps.

What is the reason for the slow development of clinical data standards? Because no one firm in the private sector can generate sufficient gains from developing clinical data standards, the development effort is voluntary, and it suffers from a lack of resources. Further, it takes time to reach consensus, and the benefits to the public are diffuse. If the public good is sufficiently large, a proper role for the Federal Government is to accelerate standards development and collaboration in the private and public sectors.

Computer-based patient records. Created in 1991, the Computer-based Patient Record Institute (CPRI) promotes and coordinates the development of CPR systems in the United States. The CPRI is composed of representatives from physician, hospital, computer system, vendor, managed care, university, and other national groups. The CPRI is working for the ubiquitous use of CPR systems in medical care, with workgroups in four areas: Codes and Structure; CPR Systems Evaluation; Confidentiality, Privacy, and Legislation; and Professional and Public Education.

Several private sector-projects are attempting to build a computer-based patient record and to export common definitions and reporting systems to all their sites nationwide. Two of these efforts have begun at Kaiser Permanente in California and at the Mayo Foundation in Minnesota.

Although there is strong interest in finding the best information systems for particular health-care organizations, there is no common method for evaluating existing systems. Additionally, there are differences in opinion regarding which costs and benefits to include in such evaluations, and how to place a value on outputs and resources that are not priced in the market place. In addition, more knowledge is needed about the technical, legal, social, and economic barriers to the development and deployment of computer-based patient record systems.

Telemedicine. In early 1994, Ameritech, Inc., demonstrated a system that enables the family of a person with a serious chronic illness to access medication at regular time intervals and to obtain direct consultation with the family physician via personal computer, television cameras, and special hook-ups. This project can reduce visits to the hospital emergency room and physician's office, while improving patient compliance with drug therapy. Another example of a personal health information system has been described above (see CHESS).

The private sector also supports several telemedicine projects such as those in Texas and Georgia. Although payment for telemedicine services has been nearly impossible to obtain from insurance programs, these projects continue to support patient care. Additionally, they are informing health care policymakers and potential entrepreneurs about the potential for cost savings and increasing access – particularly in rural areas – and about the social and legal concerns that must be addressed when providing medical care across State borders. Most of the potential savings are projected to come from reduced transportation expenses required to bring physician and patient together in the absence of telemedicine.

Community Data Repositories. Stimulated by grants from the John A. Hartford Foundation, Community Health Management Information System projects have been initiated in the States of Washington, Iowa, Vermont, New York, Minnesota, and Ohio and the city of Memphis. These projects aim to extract patient, provider, and service data from claims and encounters and store them in a shared community data repository. As desired by the community, the repository may be enhanced to include condition-specific data and patient-centered surveys.

In addition, many other health information networks are in planning stages, although without a common model for health information networks to guide them. The goal of these projects is to begin the development and implementation of local health data networks and data repositories. The expected benefits are improved health business transactions and community health data

repositories of standardized health data about the process and outcomes of health care delivery. Demonstrations such as these can show the advantages of collecting standardized health data about the community.

The potential for NII to link national and community networks with homes, offices, and health institutions to facilitate improved and cost-effective health care should be demonstrated and evaluated. This information would increase understanding about the sources of efficiency and the size of the costs relative to the benefits. Armed with this knowledge, private and public ventures, when targeted to obtain demonstrated cost savings, would be less risky.

Selected Public Activities

Department of Health and Human Services

The *National Library of Medicine* (NLM) contributes to the NII on many different levels. Foremost, NLM produces data bases and information services that provide access to the scientific knowledge underpinning biomedical research and health care. NLM's on-line data bases and data banks are the most widely used medical information resources in the world. The expanding Internet provides an enhanced vehicle for delivering NLM services – from MEDLINE to GenBank – including on-line access to clinical practice guidelines that combine images and full text; the developing "Visible Human" digital library of image data from photographic, computed tomography, and magnetic resonance imaging of complete male and female bodies for a range of educational and health care applications; and remote execution of sophisticated gene sequence matching algorithms.

Since the mid-1980's, the number of clinicians with direct access to MEDLINE has increased dramatically. More than 34,000 individual health professionals now search NLM's computer system, up from just a few hundred less than a decade ago. "Physicians report that in situations involving individual patients, rapid access to the biomedical literature via MEDLINE is at times critical to sound patient care and favorably influences patient outcomes."[9]

The Unified Medical Language System (UMLS) Project of NLM focuses on linking terms and codes in patient records to evidence-based knowledge such as that in practice guidelines and the scientific literature. Through the development of the Metathesaurus that connects the various computerized coding schemes and controlled vocabularies and an Information Sources Map that will support automated selection of data bases containing information relevant to particular information needs, the UMLS is providing tools for successful navigation among the growing number of health care information resources and for capturing and encoding patient data.

The NLM's High Performance Computing and Communications (HPCC) program funds NII applications research in the areas of test-bed networks linking health care organizations, telemedicine, and development of computer-based patient record systems, coordinating and in some cases co-funding projects with other agencies such as AHCPR and the Department of Defense, Advance Research Projects Agency. Supporting the development of computer-based patient record systems is also a priority for NLM's National Information Center on Health Services Research and Health Care Technology (NICHSR), since data collected as a by-product of current health care delivery could greatly enhance the quality and timeliness of health services research, including outcomes studies. To ensure that academic medical centers, hospitals, and members of the National Network of Libraries of Medicine can access and make effective use of the NII, NLM and the National Science Foundation are co-sponsoring a Medical Connections program to link these institutions to the Internet.

The NLM's programs to support the development of enterprise-wide Integrated Advanced Information Management Systems (IAIMS) and to provide Medical Informatics training to health and information professionals create a receptive environment for effective use of the NII. The NLM's current Director serves as the Director of HPCC's National Coordination Office, which is housed at the NLM and reports to the President's Office of Science and Technology Policy.

AHCPR, through its Medical Treatment Effectiveness Program (MEDTEP), adds to a knowledge base of medical effectiveness research findings and clinical practice guidelines that inform practitioners and their patients about what works best and for whom. AHCPR is collaborating with NLM to make guidelines available in a form compatible with NII applications. In addition, AHCPR supports the development and evaluation of computer-based patient record systems and attendant clinical computer decision support systems. AHCPR assesses their impact on the medical and cost effectiveness of health care and their potential to generate uniform, accurate patient care information for medical effectiveness researchers. Through its extramural program, AHCPR has for years supported the study of computer-based patient records and clinical decision support systems. Through its Office of Science and Data Development, AHCPR promotes the coordination of the developers of patient care data standards and the analysis of confidentiality and privacy issues concerning researcher access to patient care data.

The *Food and Drug Administration* (FDA), through its Submission Management and Review Tracking (SMART) program, is developing a consistent approach to the electronic submission and review of drug, biologic, and medical device applications. As part of this project, FDA is working with its regulated industries, the clinical community, the World Health Organization, and the European Union to enhance and standardize nomenclature for coding clinical safety data. FDA also is pursuing nomenclature and data format standards for other data elements required in product submissions, including toxicology, pathology, and patient information. These standards, coordinated with the private sector, will improve the uniformity of patient care data.

The *Health Resources and Services Administration*, through its Office of Rural Health Policy, is undertaking support of telemedicine project application and evaluation in rural areas. These applications should stimulate the outreach of NII health care applications to rural America.

The *Health Care Financing Administration* (HCFA), the Nation's largest health insurer, has the most comprehensive health care data base in the world, which supports the management of the Medicare and Medicaid programs. Much of this data is managed in a large network, linking Medicare enrollment and benefits information to both the contractor claims payment sites and providers. HCFA electronically receives more than 90 percent of the institutional providers' claims and more than 65 percent of the individual providers' claims, which collectively require HCFA to process over 500 million claims annually. HCFA agents use clinical data to assure quality and appropriateness of care provided to beneficiaries. HCFA shares this information with other organizations to facilitate research and formulate health care policy. HCFA has been an active participant in the development of data standards, and was the first among the health insurance groups to deploy electronic health insurance claims standards. HCFA is an active member in ANSI-Accredited Standards Committees and ANSI's Healthcare Standards Planning Panel. HCFA also supports research on telemedicine projects in rural areas and on payment methodology for telemedicine consultations.

In 1985, HCFA, in cooperation with the National Center for Health Statistics (NCHS), developed a process for updating and maintaining ICD-9-CM through the Coordination and Maintenance Committee. HCFA is responsible for maintaining Volume 3, Procedures, while NCHS is responsible for Volumes 1 and 2, Diagnoses. Proposed revisions to the coding system are received by the appropriate agency, researched, developed in a standardized format, and publicly presented for informational purposes. Final approval for any coding changes comes from the Administrator of HCFA and the Director of NCHS. The changes are made annually. To address the shortcomings of the ICD-9-CM procedure codes, HCFA investigated developing a new procedure coding system and contracted with 3M, Health Information Systems, Inc., to develop a prototype. Six chapters thus far have been developed, with the cardiovascular chapter being the most complete.

The *National Cancer Institute*, in addition to the PDQ program described above, is supporting the development of technology that could make use of a national broadband network capability for digital mammography. If successful, this technology could electronically transmit breast images for the purpose of obtaining rapid and

expert radiologic consultation. This future application of teleradiology requires significant improvement of digital imaging modalities to acquire primary digital images, film digitizers to translate conventional film images into digital form, digital data networks, image-processing algorithms, computer workstations, and other imaging technology.

Within the Public Health Service, Office of the Assistant Secretary for Health, the *Office of Disease Prevention and Health Promotion* is developing a community services workstation. With support from other PHS agencies and the Department of Defense, Advanced Research Projects Agency, a prototype of the workstation is being created to illustrate how information about health, education, and welfare service availability may inform a community's population.

Department of Commerce

The *National Telecommunications and Information Administration* (NTIA) was allocated $26 million for FY 1994 to support the development of the NII. The purpose of the NII is to interconnect the nation's businesses, residences, schools, health care facilities, and other public information and social service providers through broadband interactive telecommunications networks.

During FY 1994, NTIA intends to issue grants in the area of health care for pilot demonstrations that are designed to develop, demonstrate, and promote applications of information technology that will educate, restrain health care costs, improve quality, and increase access to health care, with the potential for wide-scale deployment and interconnection over NII networks.

Also within the Department of Commerce, the *National Institute for Standards and Technology* (NIST) has been active in several standards development efforts related to health care, including (1) Health Level 7 and (2) the Health Care Special Interest Group of the Open Systems Interconnection (OSI) Working Group. The purpose the OSI Working Group is to encourage broad scale adoption of medical information standards developed in the United States, leading to information systems that will exchange data with each other and operate on a variety of computer operating systems. The NIST also has a cooperative research and development agreement (CRADA) with private industry in medical information systems/architecture standards, which draws upon NIST's experience with electronic data interchange.

Department of Veterans Affairs

The *Department of Veterans Affairs* (VA) operates 171 medical centers located in all 50 States and Puerto Rico. All 171 facilities are supported with a hospital information system called the Decentralized Hospital Computer Program (DHCP). DHCP has approximately 60 public domain software modules supporting functions such as admissions, pharmacy, laboratories, medicine, order entry, health summary, engineering, purchasing, and finance. Both the Department of Defense and the Indian Health Service, as well as some State institutions, have used this public domain software, modifying it to meet their particular needs. Recent clinical releases, such as Discharge Summary, Progress Notes, Allergy Tracking, and Problem List are part of an incremental approach to automating the patient record. The Problem List serves as a point of integration, organizing patient information by clinical discipline and associating patient treatments and outcomes with problems. It also ties the automated patient record to appropriate billing procedures. The Problem List works with VA's new Clinical Lexicon; a tool that permits the user to enter a clinical term using natural language. The system then maps the term to all of the applicable coding schemes (e.g., ICD, DSM, SNOMED, CPT) and stores the term so that it can be retrieved and used by a wide variety of legitimate users of clinical data.

All VA facilities have been interconnected for the past 8 years with a digital communications network. VA is enhancing its data transport utility called Patient Data Exchange (PDX) so that VA health care facilities can exchange health summaries containing relevant clinical data across the VA network. At the Washington and Baltimore Medical Centers, VA has installed an integrated imaging project to store medical images as an integrated part of the electronic patient record. These systems have been in daily use for several years and store images from such applications as pathology slides, gastrointestinal, bronchoscopy, cardiac catheterization, echocardiography, and radiology examinations. At the

Baltimore Medical Center, the VA has built a standards-based gateway between a hospital information system and a commercial Picture Archiving and Communications System. With these capabilities, VA could be a useful test bed to determine the effectiveness of electronic data exchange between facilities and health care providers. As a result of the common software at many Federal medical care facilities, this test bed could easily be extended to other agencies as appropriate. An example could be the effectiveness of making AHCPR-sponsored clinical practice guidelines available to clinicians on VA wards using connections to Internet.

Department of Defense

The Department of Defense, *Office of Health Affairs* has supported the development of a Comprehensive Health Care System leading to six modules that are being deployed world-wide. The Department was also charged by Congress to deliver a plan for developing and deploying a computer-based patient record in military settings in early 1994.

The military's Medical Diagnosis Imaging Support System has developed and demonstrated projects that involve filmless radiology departments in hospitals, electronic transmissions of digital images via satellite, and the use of the most recent standards in digital image transmission.

Department of Agriculture

Within the Department of Agriculture, the *Rural Electrification Administration* (REA) plays a key role in the rural aspect of the NII. The Distance Learning and Medical Link Grant Program (DLMLGP) demonstrates the ability of rural communities to utilize existing or proposed telecommunications systems to achieve sustainable, cost-effective distance learning or medical-link networks. Rural schools, libraries, hospitals, health care clinics, and related organizations that operate rural educational or health care facilities are eligible. Implemented in FY 1993, the DLMLGP has selected 28 rural projects (9 medical projects) for funding, and is currently reviewing applications submitted under the second round of funding. REA funds equipment used for distance learning classrooms such as encoding and decoding devices, specialized cameras and video monitors, video switchers, microphone mixers computers, and local area networking equipment. For medical link projects, REA funds equipment used in physician consultation, teleradiology, and educating rural health care providers. Some of this specialized equipment includes teleradiology workstations, X-ray scanners, digital microscopes, and all of the above distance learning equipment.

Applicants to the DLMLGP work closely with local telecommunications providers creating a demand for bandwidth capacity and switching technology in remote areas. In this respect, the DLMLGP accelerates the development of rural networks, one of the most challenging areas of the NII.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) has been a pioneer in the field of telemedicine since the early days of manned space flight. NASA's interest in telemedicine is to understand its application to medical care in space for future long duration platforms, such as a space station, and to minimize risk to astronauts and increases probability of mission success. NASA's early efforts to monitor the health of its crew members have helped promote dramatic changes in the way medical monitoring in terrestrial medical transport is conducted in the U.S.

NASA has been involved in several telemedicine projects over the past 30 years. Space Technology Applied to Rural Papago Advanced Health Care Program (STARPAHC), brought medical care to remote areas of the Papago Indian Reservation in Arizona in the 1970s. The Spacebridge to Armenia provided satellite consultation to a disaster area in 1988. Currently, NASA is involved in a joint effort with Russia, the Spacebridge to Moscow, to link several U.S. medical centers with a hospital in Moscow. NASA's experience in telemedicine and communications technologies has helped promote the practice of telemedicine across the globe. The Armenia experience demonstrated that interactive consultation by remote specialists can provide valuable assistance to onsite physicians and favorably influence clinical decisions in the aftermath of disasters.

PART III: Where Do We Want to Be?

To obtain the benefits called for by the vision of the health care information system of the future, an advanced NII should support the development and evaluation of information technology applications that can improve patient care, both directly and indirectly. These achievements would improve the health status of communities and reduce their costs of health care. Applications that bring both higher benefits and lower costs should be carefully evaluated.

Patient care data describing patient's signs, symptoms, and conditions; treatment; and outcomes should be generated at the point of care delivery by the providers of health care. These data should be defined uniformly across all points of care, automated, and made available through the NII for direct patient care; public health policy development at community, state, and national levels; and research purposes. This sharing should occur only under conditions of confidentiality, privacy, and responsibility that are acceptable to society.

Patient care data and other information necessary in the direct care of the patient should be promptly available to providers of care at the site of care.

Clinical decision support systems should incorporate research findings based on studies of these data and on other studies. The purpose is to give providers of care information about drug interaction alerts, allergy alerts, preventive screening reminders, and other prompts that improve the delivery of health care.

Personal health information should be widely available on the NII and be accessed through personal computers and telephone links, cable television, or other links to community and nationwide networks. This linkage will permit people to obtain health care information, computer-assistance for analyzing health problems, and advice from medical professionals and from people with similar health conditions. The result of improving personal self-care and wellness should be more power in the hands of the people to influence their health and a more appropriate use of health care resources.

Public health surveillance and epidemiologic studies based on patient care data and social indicators should be available to inform public policy and to guide the provision of public health services. Information about the patient outcomes of care produced by health care providers and health care plans should be available to guide consumers in making health plan choices and to feed back information to providers of care about the patient outcomes their peers are achieving.

This information will benefit consumers in their homes, schools, and workplaces. Providers of care in physicians' offices, other ambulatory sites of care, and hospitals will have access to data about specific patients and the information, if necessary, to guide decisions about treatment alternatives and their expected outcomes. Health care managers and policymakers in health plans, public health departments, national health policy positions and other settings will be able to develop an overall picture of health care utilization to assess the allocation of health resources and whether private and public health needs are being met.

Achieving these benefits requires the development of several components of a health information infrastructure. These components are:

- *Medical information standards* for the
  - nomenclature, coding, and structure;
  - content of specific data sets; and
  - electronic data interchange

  of patient care data. They are necessary to achieve the uniformity of definition and meaning of the patient care data used in the care of the patient and in generating information about the outcomes of care. The standards will improve the sharing of patient care data across different computer information systems. The slowness of there development of these standards hinders the cost-effectiveness of clinical decision support systems in institutional and provider settings.

- *Unique personal identification* for accurate links across databases used for patient care. Although the social impact and confidentiality issues are the most important for society, technical issues still remain. Patient information must be uniquely identified and linked

across databases used for patient care. Some options are thumbprints, retinal eye scan images, DNA blood typing, or personal identification numbers in digitized form. If personal identification numbers are used, they could be social security numbers (SSN) or identifiers unique to health care.

The costs and security of different techniques to assure unique personal identity, plus confidentiality and privacy of patient care information and any information to which it may legitimately be linked, need to be investigated.

- *Model development* for health care information, reference requirements, and a reference architecture to define and relate patient care data and medical information and the clinical and administrative functions they serve. A concept model should be developed that serves as the guiding framework that shows the purpose, dimensions, and minimum characteristics of health information networks, computer-based patient record systems, and other concepts. The concept models may pertain to specific domains, such as hospitals, clinics, and local networks. These models, requirements, and architecture will provide a common framework that will allow software vendors and system designers to build software tools that can work together. If they work together, these tools can fill out, or build, the health care application architecture (the common framework). By supporting the design, building, and implementation of systems that can interact with each other, this framework, and tool development, will support improved patient care and build a path for the movement of existing systems to patient-centered systems.
- *Federal confidentiality and privacy laws* that supersede a patchwork quilt of State privacy laws. They will allow society to gain the benefits of rapid automated information transfers across States through information technology, while protecting patient care data from disclosure. They should provide penalties for inappropriate linking, use, or disclosure of patient care data and define inappropriate use.
- *Health data repositories* to maintain and assure the uniformity and confidentiality of patient care data and to provide access to the appropriate users of these data. These repositories might be distributed among local communities or located regionally across the United States. At the extreme, there could be one central or national data repository. Safeguarding the confidentiality of patient-identifiable data wherever it is stored is essential and must be a prime responsibility of the depository management.
- *Computer-based patient record system development* to capture patient data at the point of care and make it available electronically upon request of the provider for patient care. This development should extend computer-based patient record systems so they support both clinical and administrative decisionmaking.
- *Health Care Computer Laboratory (test bed) development* to determine the technical usefulness of data standards and data exchanges that support specific functions. Findings from these pilot test sites should guide modifications to data standards, models, and architectures to make them suitable for commercial applications.
- Pilot tests and evaluation of health information technology in patient care settings such as the home, physician's office, hospital, and community. These pilot tests and evaluations should include rural as well as urban settings, and consumer as well as provider settings. They should reveal where the most beneficial applications are likely to be.
- *Community trials* for applications that have been proven successful in single site settings. These trials would be linked in broad-area studies to assess their scalability (i.e., their costs and performances at different volume levels and configurations) and their success in achieving quantifiable savings that can be duplicated.
- *Specific studies* should evaluate the economic and medical feasibility of patient care data transfers between primary care physicians and specialists across geographic distances, of the use of personal home

information systems to promote wellness and efficient use of medical services, and of administrative electronic data systems to improve the efficiency of medical claims handling and payment. These transfers include telemedicine transmissions such as medical and patient images, consumer health information and decision analyses, and consultations with experts and patients with similar conditions. Additional studies should evaluate the potential for libraries of information on standard representations of medical conditions to be accessed by providers to improve their understanding of patient conditions, disease entities, and healthy body functioning which, in turn, should improve patient outcomes of care. Studies of alternative means for professional education and training using the NII should also be undertaken.

IV: How Are We Going to Get There?

Issues and Questions to be addressed

- How can the federal government facilitate a public-private partnership for the development of health care information standards? What should the priorities be among:
  - Medical information standards for the nomenclature, coding and structure, content of specific data sets, and electronic exchange of patient care data, information, and medical knowledge.
  - Standards for electronic signatures, especially for the validation of physicians' orders and other information within health information systems.
  - Standards for personal identification methods.

  With regard to personal identification, how best should the federal government examine the benefits and costs of alternative schemes, including (1) improving the Social Security Number, (2) creating and implementing a new unique health identification number for the population, and (3) adopting any other identification system, such as a private-sector numbering system, retinal scans, or fingerprint readers?
- When developing standards, data sets, and formats for regular reporting of patient care data used in the programs of federal agencies, how should the agencies work cooperatively with the private-sector standard developers to achieve common standards and to accelerate the private sector's development of standards to meet the programs' needs?
- How should federal confidentiality and privacy legislation be developed that would apply civil and criminal penalties for inappropriate use of personally identifiable patient data, including inappropriate disclosure and redisclosure of that data, and discriminatory decisions based on linking such data with other personal data bases?
  - Should this legislation supersede State privacy laws to achieve nationwide uniformity in the way the uses of personally identifiable patient data are restricted?
  - How should information system security requirements be addressed?
- How should information about the health care information system technologies being developed, placed in use, and evaluated by federal agencies be coordinated?
  - Due to the diverse missions, technologies, service delivery programs, and research and demonstration programs across federal agencies, should there be a federal work group established for coordination to reduce unnecessary duplication by sharing program information that could improve NII health care applications?
- Should the federal government support a public-private partnership to develop integrated health care information systems in hospitals, physicians' offices, and other health care settings?
  - Should this partnership develop models for health care information and reference requirements and architectures for supporting the functions that require patient care data?
  - Should this partnership develop tools for software developers and system designers?
  - Should this partnership support the development of the computer-based patient record for capturing patient care data at

the point of care for clinical and administrative decisionmaking.

- Should this support be based on a study of the expected benefits and costs of these systems and target to those areas where the benefits are most strongly expected to exceed costs?
- Should this support include a portion of the capital cost of these systems?
- Should this support be coordinated with existing telemedicine projects aimed at increasing health care access for rural populations?
- Should this support include investigating the training necessary for these systems to be adopted by health professionals and their staffs?

■ Should the federal government undertake a program of research, demonstration, and evaluation of integrated health care information systems to identify the specific applications for which the benefits exceed the costs?

- Should this program participate with the private sector in the funding of pilot tests of these systems in single-site pilot tests, multiple-site trials, and community-wide demonstrations?
- Should this program be coordinated with standards developing efforts to test preliminary standards and provide feedback to the developers for revisions to the preliminary standards?
- Should this program support demonstrations that show the benefits and costs of linking clinical decision support systems in hospital and physician office settings to national sources of medical knowledge?
- Should this program support demonstrations showing the value of personal health information systems that provide access to health care knowledge to individuals in their homes, in their workplaces, and in public libraries?
- Should this program investigate the costs and benefits of nationwide networks for carrying out administrative health care functions, including enrollment, eligibility checking, claims processing, and electronic funds transfer?
- Should this program investigate the potential administrative and clinical cost savings, the changes in health care service utilization behavior, and the change in consumer satisfaction from providing access to financial and medical effectiveness information to community populations and their health care providers?
- Should this program investigate the expected changes in the process of health care and in the patient outcomes of care that result from use of clinical decision support systems in relevant health care settings that are linked to national information sources?

■ Should the federal government support a public-private partnership to develop Federal strategies for repositories of health care data?

- Should this partnership fund workshops and projects that support the development of important community issues, new concepts and policies concerning health care data that will be needed for addressing control, access, and accountability questions in the NII?
- Should a research program investigate the value of community health care data repositories for efficient and effective deliver of health care services and for improving patient outcomes in the community?
- Should Federal support include partial funding of community health care data repository demonstrations?
- Should Federal support include funding evaluations of the community uses of their own data, determining what are the benefits to the community, who else receives benefits from such repositories, and what are the costs of achieving those benefits?

■ Should the federal government support State efforts to use the NII to promote and evaluate the public health of their populations and the administrative efficiency of their health care programs?

- Should there be Federal support for States to demonstrate the benefits to state and local public health functions of community data repositories linked at the state level?

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A Transformation of Learning: Use of the NII for Education and Lifelong Learning

DRAFT FOR PUBLIC COMMENT

Today, we have a dream for a different kind of superhighway that can save lives, create jobs and give every American young and old, the chance for the best education available to anyone, anywhere.

I challenge you . . . to connect all of our classrooms, all of our libraries, and all of our hospitals and clinics by the year 2000.

Vice President Al Gore, speaking to communications industry leaders, January 11, 1994

PART I: What Is the Application Area?

Description of Education and Lifelong Learning

Communications technology is transforming the way we live by connecting us with information and each other. The National Information Infrastructure (NII) promises every business, government agency, hospital, home, library, and school in the nation access anywhere to voice, data, full-motion video, and multimedia applications. The impact of these capabilities on learning – for the children, for higher education students, and for lifelong learners – will be substantial.

The way Americans teach, learn, transmit and access information remains largely unchanged from a century ago. We find the following conditions in American education and training:

- The textbook remains the basic unit of instruction. Absorption of its contents tends to be the measure of educational success.
- Teachers and instructors use "chalk and talk" to convey information. Students are often recipients of instruction rather than active participants in learning.
- School teachers work largely in isolation from their peers. Teachers interact with their colleagues only for a few moments each day. Most other professionals collaborate, exchange information and develop new skills on a daily basis.
- Although half of the nation's school teachers use passive video materials for instruction, only a small fraction have access to interactive video, computer networks, or even telephones in the classroom.
- While computers are a frequent sight in America's classrooms and training sites, they are usually used simply as electronic workbooks. Interactive, high performance uses of technology, such as networked teams collaborating to solve real-world problems, retrieving information from electronic libraries, and performing scientific experiments in simulated environments, are all too uncommon.

- "U.S. schooling is a conservative institution, which adopts new practice and technology slowly. Highly regulated and financed from a limited revenue base, schools serve many educational and social purposes, subject to local consent. The use of computer technology, with its demands on teacher professional development, physical space, time in the instructional day, and budget ... has found a place in classroom practice and school organization slowly and tentatively." [1]

Events of the last two decades have proven that we can do better. We have found that most American children are capable of learning at dramatically higher levels—levels of performance we now expect only of our best students. We have learned this from research in cognitive science, from the educational achievements of other countries, and from pioneering efforts in our own schools. Moreover, after 35 years of research, we have found that technology can be the key to higher levels of achievement. [2]

Similarly, in the American workplace we have found that workers can achieve levels of productivity and quality equal to the best in the world. [3] Well-educated, well-trained, motivated workers can produce high-quality goods and services at low cost, enhance industrial productivity and competitiveness, and sustain high living standards. High-quality education and training pay off for the individual whose skills are upgraded, for the company seeking a competitive edge, and for the nation in achieving overall productivity and competitiveness.

Our major foreign competitors place much greater emphasis on developing and maintaining workforce skills than we do. Experienced production workers at Japanese auto assembly plants, for example, receive three times as much training each year as their American counterparts. Research in our country has shown that workers who receive formal job training are 30 percent more productive than those who do not. Again, we have found that technology is the key to making training accessible and affordable—especially for small- to medium-sized firms with few resources of their own to devote to producing and implementing the training and lifelong learning their workers need and for workers who, on their own, are attempting to improve their skills or transfer them to new areas of endeavor.

Finally, in preparing students for the workplace, we have learned that interactive, high performance technology can produce immersive, real world instructional environments. These environments can smooth longterm school-to-work transitions while helping to meet the immediate objectives of both schools and workplaces. Our efforts to develop this capability have been fragmentary and shortlived at best.

A Vision for the Use of the NII

The NII, will be the vehicle for improving education and lifelong learning throughout America in ways we now know are critically important. Our nation will become a place where students of all ages and abilities reach the highest standards of academic achievement. Teachers, engineers, business managers, and all knowledge workers will constantly be exposed to new methods, and will collaborate and share ideas with one another.

Through the NII, students of all ages will use multimedia electronic libraries and museums containing text, images, video, music, simulations, and instructional software. The NII will give teachers, students, workers, and instructors access to a great variety of instructional resources and to each other. It will give educators and managers new tools for improving the operations and productivity of their institutions.

The NII will remove school walls as barriers to learning in several ways. It will provide access to the world beyond the classroom. It will also permit both teachers and students access to the tools of learning and their peers—outside the classroom and outside the typical nine to three school day. It will enable family members to stay in contact with their children's schools. The NII will permit students, workers and instructors to converse with scientists, scholars, and experts around the globe.

Workplaces will become lifelong learning environments, supporting larger numbers of high skill, high wage jobs. Printed books made the content of great instruction widely and inexpensively available in the 18th Century. The interactive capabilities of the NII will make both the

content and interactions of great teaching universally and inexpensively available in the 21st Century.

Education and Lifelong Learning Applications for the NII

The NII will provide the backbone for a lifelong learning society. Education and training communities will better accommodate an enormous diversity of learners in an equally diverse variety of settings. In addition to schools and workplaces, interconnected, high-performance applications will extend interactive learning to community centers, libraries, and homes. Education, training, and lifelong learning applications available from the NII may include:

- Multimedia interactive learning programs delivered to homes to immigrant children and their parents to collaborate on learning English as a second language.
- Troubleshooting and operating applications that access the computer-assisted-design (CAD) databases used to design workplace technology and to integrate the CAD data with instructional and job-aiding capabilities to provide just-in-time training and maintenance assistance.
- Comprehensive interconnectivity for students that allows them to receive and complete assignments, collaborate with students in distant locations on school projects, and interact with teachers and outside experts to receive help, hints, and critiques.
- Simulated learning activities such as laboratory experiments and archeological digs.
- Universal access interfaces for computers and telecommunications devices for students, workers and others with disabilities to allow access to the NII.
- Affordable, portable personal learning assistance that tap into the NII from any location at any time and provide multi-media access to any NII information resource.
- Immersive, realistic interactive simulations that allow emergency teams made up of geographically dispersed members to practice together on infrequently used procedures that may be urgently needed to meet local exigencies.

The Educational Benefits of Technology

Evidence from research, schools, and workplaces around the country tells us that communications technologies are powerful tools in reaching the highest levels of educational performance.

- Students with disabilities, who previously had at best limited access to most educational and reference materials, will have fuller access and will have the ability to participate in the learning experience with their peers.
- A 1993 survey of studies on the effectiveness of technology in schools concluded that "courses for which computer-based networks were used increased student-student and student-teacher interaction, increased student-teacher interaction with lower-performing students, and did not decrease the traditional forms of communications used." [4]
- Research on the costs of instruction delivered via distance learning, videotape, teleconferencing, and computer software indicates that savings are often achieved with no loss of effectiveness. Distance learning vastly broadens the learning environment, often providing teaching resources simply not available heretofore. Technology-based methods have a positive impact on learner motivation and frequently save instructional time. Savings in training time produce benefits both by reducing training costs and by shortening the time required to become and remain productive in the workplace.
- A review of computer-based instruction used in military training found that students reach similar levels of achievement in 30% less time than they need using more standard approaches to training. [5]
- A Congressionally mandated review covering 47 comparisons of multimedia instruction with more conventional approaches to instruction found time savings of 30%, improved achievement, cost savings of 30-40%, and a direct, positive link between amount of interactivity provided and instructional effectiveness. [6]

- A comparison of peer tutoring, adult tutoring, reducing class size, increasing the length of the school day, and computer-based instruction found computer-based instruction to be the least expensive instructional approach for raising mathematics scores by a given amount. [7]
- A landmark study of the use of technology for persons with disabilities found that "almost three-quarters of school-age children were able to remain in a classroom, and 45 percent were able to reduce school-related services." [8]

Of course, these benefits depend upon several contextual factors, including the instructional methods used, the quality of the applications, the availability of professional development for educators, accessibility of instructional materials, the presence of school technology support staff, and family involvement. [9] We must learn through experience how best to ensure that the benefits we intend to obtain from NII-based applications become routinely realized in practice.

Telecommunications networks provide a range of resources to students and educators that were never before available or affordable. Students and workers can now gain access to mentoring, advice, and assistance from scientists, engineers, researchers, business leaders, technicians, and local experts around the globe through the Internet, using a level of access and connectivity that was previously unimaginable. High school students in West Virginia, for example, can now study Russian via satellite and telephone with a teacher hundreds of miles away. Few West Virginia school districts could afford to offer such a course any other way.

Less well understood are changes in the types of learning that occur with the use of certain technologies. Current evidence suggests that some technology applications are more effective than traditional instructional methods in building complex problem solving capabilities for synthesizing information and in improving writing quality. The effects are achieved in part by permitting alternate methods of "reaching" and motivating learners.

The Administration's National Information Infrastructure initiative can trigger a transformation of education, training, and lifelong learning by making new tools available to educators, instructors, students, and workers and help them reach dramatically higher levels of performance and productivity. The impact of this transformation in teaching and learning is inestimable, but clearly enormous. Knowledge drives today's global marketplace. The NII will permit us to take learning beyond the limitations of traditional school buildings. It will take our educators and learners to worldwide resources. Learning will be our way of life.

PART II: Where Are We Now?

Today, compelling teaching and learning applications are the exception, not the rule. Several federal agencies provide services that meet specific, focused needs, while hundreds of state and local networks and private service providers have begun to address the technology needs of education. Current uses, while expanding rapidly, reach only a small number of technologically-literate school communities.

Current application of NII capabilities to workplace training is more extensive and technologically advanced than educational applications, yet it lags well behind what is needed and available. The story of workplace training seems to be a case of the haves receiving more and the have-nots remaining neglected. Small firms, those with 100 employees or less, provide about 35 percent of total U.S. employment, but they lack the expertise to provide in-house training, the resources to pay for outside training, and sufficient numbers of people who need training at any one time to justify focused training efforts. Larger firms are more likely to provide training than smaller ones, but the training they provide is mostly limited to college-educated technicians and managers. The lower the level of skills possessed, the less likely the worker is to receive training from any source. Transportable, quality controlled training and lifelong learning could be made readily and inexpensively accessible using the NII and will have a major impact on improving worker skills and workplace productivity.

While much remains to be done, the opportunities offered by the NII put many of the needed capabilities within reach of schools, homes, and the workplace.

Current Uses of Telecommunications for Education

The existing telecommunications infrastructure is composed of telephone, broadcast, cable, and electronic networks. It is used for education, training, and lifelong learning in five basic ways: 1) instructing with video; 2) gathering information from remote libraries and databases; 3) communicating using two-way asynchronous capabilities such as e-mail and information bulletin boards; 4) distance learning; and 5) electronic transfer of instructional software and simulations.

- Instructional video. Seventy-five percent of America's schools have cable television, and half of its teachers use video material in their courses. [10] The Stars Schools program is reaching 200,000 students in 48 states with advanced placement courses in mathematics, science, and foreign language instruction using fiber optics, computers, and satellites. [11] Cassette videotapes for instruction are widely used in schools and workplaces, and the development of these videotapes for both education and training has become a vigorous industry.

- Information collection. This activity includes location and retrieval of documents such as lesson plans and research reports, but it also includes newer data sources such as CAD databases for workplace technologies and equipment, and multimedia information retrieval from digital libraries that can be accessed by students, workers, or people in homes, libraries, and museums. Over 60,000 electronic bulletin boards are used by more than 12 million Americans every day. [12] The annual rate of Gopher traffic on the Internet, which directly represents an effort to use NII facilities to gather information, is growing at an annual rate of approximately 1000%. [13] The Department of Education has a Gopher server which points to or contains educational research information, such as the AskERIC service and information from sources such as CNN, Academy One, and the Educational Testing Service. NASA Spacelink makes lesson plans on space flight and related science topics available on the Internet.

- Two-way communication. This includes communication via electronic mail and conferencing among teachers, students, workers, mentors, technicians, and subject matter experts of every sort. Approximately one-quarter of the teachers in Texas regularly sign on to the Texas Education Network, or TENET, to share information, exchange mail, and find resources. A professor at Virginia Polytechnic Institute and State University teaches a writing course entirely online. Students swap writing projects and discuss their assignments online. In the workplace, electronic mail is used by more than 12 million workers, increasing to over 27 million workers by 1995. Just less than a sixth of U.S. homes now have at least one computer connected to a modem, and this percentage is growing rapidly. [14] As of July, 1993, there were four Internet hosts for every 1000 people in the United States. There are now 60 countries on the Internet. About 137 countries can now be reached by electronic mail. [15]

- Distance learning. Hundreds of thousands of students in schools, community colleges, and universities now take courses via one- and two-way video and two-way audio communication. In South Carolina, high school students across the state study with a teacher of Russia based in Columbia through South Carolina Educational Television. Boise State University offers a masters degree program conducted entirely over networked computers to students all over the country. The Department of Defense is investing well over $1 billion in the development and implementation of networked distributed interactive simulation. This technology, which allows dispersed learners to engage in collaborative problem solving activities in real time, is now ready for transfer to schools and workplaces outside of the defense sector.

- Transfer of instructional software and simulations. Instructional programs, simulations, materials, and databases can all be accessed over the NII and delivered to schools, homes, libraries, and workplaces wherever and whenever it is desirable to do so. Currently, there are massive exchanges of software, databases, and files using the Internet, but relatively little of this activity occurs in the service of education, training, and lifelong learning.

Nonetheless, compelling applications that will become indispensable to teachers, students, and workers are not yet available. All the capabilities of computer-based instruction and multimedia instruction can be distributed using NII facilities to schools, workplaces, homes, libraries, museums, community centers, store fronts—wherever and whenever people wish to learn. Yet the infrastructure and applications to support this level of accessibility for education, training, and lifelong learning uses have yet to be developed. Until compelling applications are available, educations will not realize the potential of the NII.

Efforts to Build the NII for Education and Lifelong Learning: Roles of the Private, Nonprofit, and Public Sectors

Successful implementation of the NII to serve the nation's education and lifelong learning needs will require significant contributions by the private sector, state and local governments, the federal government, and the non-profit sector.

- The private sector's role in providing telecommunications services and applications for education and lifelong learning has been expanding rapidly in recent years, and should continue to do so. The private sector will build the telecommunications infrastructure and must also make 75% to 95% of the nation's investments in applications development for education and lifelong learning. The private sector also supports the bulk of job training costs. On the telecommunications side, Pacific Bell has committed to providing data links for all California schools, colleges, and universities. On the applications side, the Software Publishers Association reports that education is its fastest-growing product category, with over 700 firms currently producing educational software.
- State and local governments provide 93% of the nation's investment in elementary and secondary education and provide a large percentage of the investment in higher education. Accordingly, most of the spending on hardware, software, professional development and support services will come from state and local public funds. In addition, states are in the position to remove regulatory and tariff barriers to NII access in the local communities.
- The federal government has three principal responsibilities. It facilitates the private sector investment in infrastructure and applications for education and lifelong learning by creating incentives, removing regulatory barriers, establishing standards, supporting research, evaluation and prototype development, developing visionary "benchmark" applications, and providing assistance to the education and training communities. It communicates a vision for the education, training, and lifelong learning uses of the NII. And, most importantly, it promotes access for all learners to the resources of the NII.
- Thousands of private nonprofit organizations, ranging from large national industry associations to small, informal groups serving Internet users with specialized interests, now serve critical roles as providers of information, technical assistance, and valuable applications.

Key Federal Agencies

While almost every Federal agency supports instructional activities that involve telecommunications technology, eleven agencies actively support the development of instructional uses of the future NII.

The Department of Agriculture collaborates with land-grant colleges and universities to make an array of information and expertise available online and to provide distance learning opportunities ato urban and rural communities.

The Department of Commerce provides support and direct funding for telecommunications infrastructure planning and development, and plans to support improvements in workplace training using the NII. Commerce's National Institute of Standards and Technology supports standards development.

The Department of Defense provides lifelong education and training to hundreds of thousands of military personnel. It supports R&D for education and training and is expected to transfer knowledge and software to schools and non-Defense workplaces under its Dual-Use and Technology Reinvestment programs. The Department of Defense Dependents Schools are expected to serve as a testbed for new applications.

The Department of Education advocates for the needs of all learners in the development of the NII. The Department is the principal source of Federal support for distance learning, via the Star Schools Program. In FY 1995, the Department will also support applications and programming development, pilot projects, teacher networks, research, and planning grants to states and districts.

The Department of Energy is in the forefront in the development and use of information technologies, such as high performance computing, high speed networking, data storage and data bases, and other information services and system integration technology. The Department is developing K-12 computing and communication applications that support a new learning paradigm and take advantage of the regional presence and capabilities of the Department's laboratories. Emphasis is placed on reaching a broad range of students, including women and underrepresented minorities. The Department will initiate pilot projects that have scalability as an important characteristic so that schools can bridge the period until network and system costs decline to the point that the education establishment can take over this support. Another key technology initiative is the development of digital libraries that will enable users speedy and economical access to Energy information over an electronic data highway.

The Department of Housing and Urban Development has undertaken an initiative to develop the capability to provide training to HUD employees and clients by linking trainers to students who may be thousands of miles apart. This distance learning network makes use of computer, interactive video, satellite, and telecommunications technologies, and will be implemented under the auspices of the recently established HUD Training Academy.

The Department of the Interior has several activities underway to implement the NII within the Department. One of these is the National Biological Information Infrastructure, which will allow users to access, manipulate, organize, and use biological data and information from a variety of sources.

The Department of Labor has direct and indirect interaction with employers, workers, business and labor organizations, and other government entities and administers most Federal training programs. The Department hopes to use the NII to enhance the skills, education and training of the American workforce.

The Federal Communications Commission regulates interstate and foreign telecommunications by radio, television, wire, satellite, and cable. The FCC is responsible for the orderly development and operation of broadcast services and the provision of rapid efficient nationwide telephone and telegraph services at reasonable rates.

The National Aeronautics and Space Administration continues to build on its HPCC program, its aeronautics and space science research and engineering missions, and its existing education outreach infrastructure to facilitate the general development of the NII to support mathematics, science, and engineering education in K-12 education. This program consists of pilot projects at 7 NASA Centers involving many of their local schools and school districts. The goal of the K-12 effort will be to produce and distribute curriculum materials to a very broad user community over the Internet. A video is in production in cooperation with the Department of Education to provide guidance on

appropriate steps for implementing Internet access and utilization in the classroom. NASA continues to operate and improve its "Spacelink" computer information system for the education community, principally teachers and students.

The National Science Foundation supports research on digital libraries for capturing, categorizing, and organizing data of all forms (text, images, sound, speech) in electronic form to allow utilization of networked databases distributed around the nation and the world. A networking infrastructure for education program will establish test beds and implement prototypes that explore the role of electronic networks in support of reformed education. The NSF will also support the development of national facilities and centers such as NSFNET, High Performance Computing and Communications Centers and National Challenge Centers needed to support the research, education and training activities required to broaden the impact of the NII.

In addition, the High-Performance Computing and Communications initiative, an interagency effort under the aegis of the Office of Science and Technology Policy, includes several components that directly support the development of NII uses for education, training, and lifelong learning. These include:

- The National Research and Education Network (NREN). The NREN will establish a very fast communications infrastructure for research and educational use. NREN efforts include increasing the availability of advanced network products and services at affordable cost to research and education communities.
- Information Infrastructure Technology and Applications (IITA). This component supports the development of software, interfaces, and tools necessary for the educational use of the NII, including access to digital libraries.

State and Local Agencies

States and local communities have initiatives to provide Internet access and high speed access to the NII for education and lifelong learning. More than half the states sponsor broad educational networking. In some states, the state government has led the effort, in others, regional or local organizations have taken the initiative as illustrated in the examples that follow.

- The Iowa Communications Network (ICN) currently includes over 2,600 miles of fiber optic cable that links together fifteen regional centers, three regent universities, and Iowa Public Television. Current uses include 63 semester-long distance learning courses offered in the fall of 1993, workshops and seminars for educators, and town meetings. Ultimately, ICN will link up every college and high school in the state. The state has invested over $100 million in ICN so far. [16]
- In May, 1993, North Carolina Governor Jim Hunt announced the North Carolina Information Highway, an effort to link educational, medical, economic development, and public safety organizations statewide. In January, 1994, Governor Hunt announced the first 106 sites to be linked up to the information highway, most of which are educational institutions. The state legislature created a school technology commission to examine the technology needs of the state's schools. The legislature is scheduled to vote on a $350 million proposal to fund educational technology in late 1994.
- In Ohio, a number of local and statewide organizations are now working to increase access to networks for educational use. These include the State of Ohio Network for Integrated Communications, which provides connectivity for all state agencies; the Ohio Educational Computer Network, charged with developing K-12 educational links; Cleveland FreeNet, a regional network; and the Ohio Academic Resources Network, linking up colleges and universities. Comparatively little state money has been spent to build these networks. [17]

Use of Telecommunications Technologies in Schools

While computers and some communications capabilities are present in American schools, high speed communications technology is limited to very few classrooms. Substantial local infrastruc-

ture investments will be necessary to realize the promise of NII applications. The installed base of computers, modems, networks, and video technology indicates that growth has been, at best, uneven. Since education and training application development has not kept pace with other grand challenges types of NII applications, most schools, communities, and state and local governing bodies have neither recognized nor acted on the need to build the technological capability to access the information superhighway. A key but not well understood requirement is for technical expertise to install and maintain high speed connections to the NII. Once the high speed communications linkages of the NII are brought to the schoolhouse door, the challenge is to build the internal high speed linkages within the building to connect the user hardware.

The installed base of computers in American elementary and secondary schools is largely incapable of supporting multimedia graphical applications because of obsolete or obsolescent hardware. Eighty percent of the base includes 55% Apple IIs and 24% IBM PCs, XTs, ATs or similar class machines, with limited modern graphic or multimedia capabilities; the part of the base made of 10% Apple Macintoshes and 8% IBM compatible 386s or 486s is capable of supporting high level applications. The number of computers in the schools, 2.5 million, is equivalent to one per classroom.[18] In a 1993 survey of NEA members, only 4% of teachers reported having a modem in their classroom, while 38% reported having access to a modem somewhere in the school building. [19] Another survey found that among 550 educators who are actively involved in using telecommunications, less than half have access to the Internet. They use the Internet services twice as often for professional activities as for student learning activities. [20]

Use of Telecommunications Technologies in the Workplace

Well-designed technology-based training can provide greater mastery of material in less time and with higher employee satisfaction than the average classroom lecture, yet classroom instruction remains the most common formal training method in the United States. [21] Most corporate trainers have insufficient experience with technology to use it confidently or to design courses around it. Although 35 million adults have difficulties with common literacy tasks, no more than 15 percent of literacy providers use them regularly for instruction, and many do not use them at all. [22] Despite the explosion of cable, public, and commercial television channels, there are only a few instructional television programs that target adult literacy. This situation remains despite the privacy and accessibility that technology and the NII offer adult learners.

The issue is not limited to the literacy training adults need to obtain and keep employment. Even among those who are prepared to benefit from them, the immersing, tutorial interactions of instruction and especially instructional simulations that are now available from high-performance technology are rarely found in the workplace. Even the capabilities of just-in-time and just-enough training and job performance aiding are rarely employed to their useful limits.

Equity and Access

Computer technology is unevenly distributed in our schools today when measured by computer density, the ratio of computers to students. Those schools in the top quintile have nine times as many computers as those schools in the bottom quintile. Computer density in the schools is not strongly correlated with socio-economic, racial, or ethnic patterns, however. Lower than average computer densities are found in large schools, urban schools, both private and parochial schools, and schools with large numbers of Hispanic students. Because the installed base is 80% obsolete, it is not a significant indicator of utilization of modern technology.

Distribution of video technologies such as distance learning equipment, VCRs, and cable TV is more evenly distributed. Schools in rural and poor areas actually have higher densities of these types of equipment. For instance, every school in West Virginia, regardless of its location, has a satellite receive-only dish providing ready access to televised courses.

Dramatic disparities appear in the area of computer networking. Instructional networks are most prevalent in the Northeast, in suburban

schools, in schools whose parents' education is "said to be above average," and also in elementary schools receiving Chapter I support, a reasonable measure of poverty.

Although most schools' use of technology is far below what they desire, because the technology is not affordable, a small number of schools have made substantial investments in technology. Such schools achieve greater "high end" technology usage. Higher socioeconomic level schools also are more likely to be high-end technology users.

A disparity in technology investments between small and large firms is noted, small firms can make only limited investments in training, with or without NII support. When such investments are made, they appear to pay off. A Canadian study found that successful companies innovate and spend more on technology than those that are less successful. [23] However, entry level training to facilitate school-to-work transitions remains everyone's stepchild. Some of the entry level training needs are being met by electronic home learning. In fact, education software sales for the first three quarters of 1993 were up 46% from the same period in 1992. [24] Nonetheless, the situated apprenticeship training and basic skills training that forms the foundation for entry level training that could be provided through the NII remains to be developed. Without accessibility to such workplace training technical capabilities, intractable inequities are likely to remain.

PART III: Where Do We Want to Be?

The goal of the Administration – as stated by Vice President Al Gore – is for all citizens to use the NII from every home, library, workplace, community center and classroom in the nation. The NII will support lifelong learning opportunities for an enormously diverse community of learners.

This goal implies nothing short of a complete transformation of American education and lifelong learning. The NII will enable education to become a lifelong enterprise for all Americans, integrating and substantially enhancing school, community, and workplace learning and providing opportunities accessible to all.

Immediate Objectives

We propose the following objectives as goals for the near term:

- Schools, libraries, workplaces, and other learning sites will have high speed access to the NII, capable of supporting interactive, multimedia applications.
- Interactive, multimedia, high-quality educational applications for students in the basic learning areas and at different skills levels will be affordable and readily available in the marketplace.
- Schools will have internal networking capabilities and hardware capable of supporting high-quality applications.
- High-quality basic skills training that provides every motivated worker with the verbal and quantitative skills needed to learn and perform job-relevant tasks will be available in every workplace.

The following conditions should exist in support of the these goals:

- Educators and the public will understand the potential of the NII to support high-performing learning environments, and they will be able to use NII resources effectively. Examples of the effective use of the NII for education, training, and lifelong learning, and evidence of concrete instructional benefits, will be widely available.
- All states, and a majority of school districts, will have comprehensive plans in place for the integration of technology into education and lifelong learning, that are linked to systemic education improvement plans, and will have begun implementation of these plans. At a minimum, these plans will address the challenges of diminished budgets while meeting requirements for increased investments in technology, professional development, maintenance, and technical support; provision for access by users with disabilities; provide broadband access to classrooms and other learning sites; and make changes in regulatory structures to facilitate infrastructure and applications investments.

- Investment by all levels of government in research, development, and evaluation, implementation, and technical support will increase dramatically. The investments will include professional development and technical assistance for teachers, school administrators, instructors, and managers in the use of information technologies. Providers of professional development and technical assistance will be encouraged to offer quality, easily accessible services in a variety of ways—including access through the NII. A majority of teachers will have access to personal telecommunications devices and networking services to support continuing professional growth and interchange of professional information.

- The demand for high-quality software packages and tools for education, training, and lifelong learning will grow rapidly and substantially such that the private sector will make massive new investments in the infrastructure and increase the quality and accessibility of the software packages and tools.

- Multimedia education and training packages will become portable so that they can be delivered across the NII and used when they reach their destination regardless of the hardware platform to be found there.

- Strategies and standards will be available for making at least the current generation applications accessible to users with disabilities or who are experiencing limitations due to aging.

Long Term Goals

To serve the needs of the educational community in the long term, an improved NII must have the following attributes:

- Convenient and equitable access. Connection to every American classroom, public library and other learning locations will ensure that NII applications are available to all citizens as instructional tools and not available just as special, rationed services. Affordable workplace and home access will give all learners access to the NII resources whenever and wherever they are needed, will enable family members to be fully involved in the education of their children, and will allow workers to participate in a productive, lifelong learning society.

- High sped transmission capability. The NII will permit the interactive transmission of voice, video, data, multimedia applications, and other digitized information at the capacities needed to support education, training, and lifelong learning.

- Easy use. User interfaces will be simple and easy to use. Networks and applications will be interoperable, to permit easy access from all hardware platforms to the widest possible array of resources. The NII will have directories and other exploration tools that allow students, teachers, and workers to make their way conveniently through the massive amounts of available information. Tools to assist users identify resources will be developed.

- Technological simplification. Telecommunications hardware and software will be simplified so that connecting a computer to the NII is no more complex than connecting a telephone.

- Accessibility. User interfaces and information must accommodate users with a widespread range of abilities through built in interface options, flexibility, and compatibility with special access technologies.

- Security. The NII will accommodate security systems adequate to protect privacy, the confidentiality of sensitive information, and to safeguard intellectual property rights. The network must also accommodate varying levels of access to resources in education and training settings.

- Content. The NII must offer information, communication, and learning opportunities that meet high standards of quality and help America reach the National Education Goals.

- Portability. Interactive courseware will have the same operating interoperability—"plug and play"—now available in high fidelity audio systems. Investments in multimedia education and training programs will be

preserved through NII delivery using interoperability standards in the development of software and hardware.

- Instructional delivery. Instructional delivery will provide workers with a "PhD in a pocket." Instruction and job performance aiding will be delivered on a device that resembles a pocket calculator. Every complex device will include sufficient embedded training and user assistance to make it easily useable.

- Instructional intelligence. Instructional intelligence will support integrated individualized tutoring that integrates goal setting, instruction, job performance aiding, and decision aiding into a single package. Natural language interaction will be an essential feature of this capability.

- Institutional integration. Institutional integration will be the most difficult challenge to meet. The new instructional capabilities will first have to be integrated into the routine, daily practice of our current instructional and workplace institutions. Just-in-time and just-enough training that is universally available will not only change the ways people are treated in the workplace but the workplace itself.

PART IV: How Are We Going to Get There?

Making the NII a reality for education will require significant capital investments by the private sector and commitments to meet continuing operating costs. Federal, State, and local governments need to create the conditions in which this investment can proceed, and will play a critical role in "jump starting" educational applications and access to the network. The following questions are intended to focus attention on the most important issues for Federal policy.

Issues and Questions to be Addressed

Access

How can the Federal Government facilitate the connectivity needs of schools and other learning sites? Should schools that have been traditionally underserved be given special attention with respect to network access and access to the information resources relevant to their needs? Should schools and other learning sites be given universal service to ensure the delivery of service at the same affordable rates as most American homes?

How can the NII be made accessible in a variety of learning environments? How can the NII allow individual learners access to the resources they need when and where they want access? How can the NII provide the capability for learning on demand through education and training programs funded by the Federal Government?

What incentives, regulatory actions, or other activities within the private sector and state and local government are needed to encourage investments to connect educational institutions and other learning sites to the NII?

Should the FCC propose regulations that enhance the availability of advanced telecommunications services to all educational institutions mby mechanisms such as preferential rates for telecommunications services? Are there alternative means of achieving this public requirement?

Should the Federal Government collect and publicly report data to monitor progress in areas such as the extent of network access in schools?

Professional Development

Teachers, administrators, instructors, and others need access to professional development opportunities on a much wider scale than is now the case. How can the Federal Government facilitate access to on-site and on-line assistance? Should professional development be expanded to include the new role of the teachers and trainers as guides and mentors rather than their present role as the primary information provider in the classroom?

Development of Education and Training Applications

Should the Federal Government target investments for the development of high quality applications for education, training and lifelong learning use of the NII that meet challenging content and performance standards? What incentives and guidelines should be developed to

encourage software developers and other producers of education and training materials to participate in developing new technologies and applications to address the needs of diverse and special needs populations?

Research and Development

What categories of research and development should be identified across the agencies of the Federal Government to ensure technology-supported learning is being pursued in conjunction with the development of the NII? Should the Federal government require evaluation of all supported projects?

How can the teachers, trainers and other educators who are actively using the NII best be supported and their work disseminated? How can the intellectual property rights of those creating applications of the NII for learning best be protected?

Planning

How can the Federal Government best support State and local efforts to develop and implement technology plans? Should the Federal Government ensure a coordinated approach between states? Within each state?

Technical Assistance

How can technical assistance best be provided by the Federal Government in response to a general or specific request from any segment of the learning community? Should the Federal Government establish specialized teams (composed of Federal staff or contractors) to assist schools, districts, state agencies? Should technical assistance networks of expert staffs be available to answer questions about NII uses for education and lifelong learning? Should planning tools be developed and disseminated, such as videotapes, planning guides, directories, resource listings and other forms of information?

Partnership

What is the role of the Federal Government in developing sustained public and private partnerships to support education and training uses of the NII?

How can the Federal Government best promote the goals of the NII and its application to education and lifelong learning with the public, with state and local governments, and with the education and training communities?

What role should the Federal Government play in making public and private information resources available to schools, institutions of higher education, training institutions, libraries, and other institutions of learning?

How can the Federal Government facilitate a public-private partnership for the development of interoperability standards, application quality standards, and effectiveness standards to facilitate the development of high-quality telecommunications and applications?

How can the Federal Government best ensure collaboration among the agencies to bring together technical expertise and application development to expand the use of the NII for education and training?

How can the Federal Government best support research and evaluation on the education and training applications of current and emerging technologies to the NII?

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Environmental Monitoring and the NII

DRAFT FOR PUBLIC COMMENT

PART I: What Is the Application Arena?

Description of Environmental Monitoring

Environmental monitoring is fundamental to our ability to understand and predict changes in the environment, and to respond to the range of environmental issues facing the Nation today. It starts with the multitude of systems for space-borne, airborne, land-based, and ocean-based observations of physical, chemical, and biological characteristics and extends to dissemination of such information for safeguarding public health, life, property, and our Nation's natural and cultural heritage. It is absolutely essential for supporting the range of human endeavor, including transportation, commerce, education, and day-to-day activities. It encompasses phenomena both natural and man-made that occur on scales from seconds to millennia and from local to global.

Just as we monitor financial, labor, and other indicators of economic health, so must we monitor environmental indicators to judge the state of the environment. Environmental monitoring tells us how well we are conserving biodiversity, how our activities are impacting the planet, and how to plan for and assess environmental remediation actions. Our national capability to perform comprehensive environmental monitoring is currently limited by an infrastructure that is extremely fragmented and which will not allow the kinds of capabilities envisioned for a multidisciplinary and global view of the environment. An improved NII will be a critical link in supporting the process of environmental observation, analysis, and information dissemination.

The Vision: Develop a nationally integrated network of observing systems, computational centers, archives, libraries and information dissemination systems to address the Nation's needs for environmental data and information. Such an infrastructure will serve as an enabling integrating agent for the diversity of observational data and information by building upon the national investment (both public and private) in environmental monitoring and protection activities.

Historically, environmental monitoring has been limited by our lack of understanding of the "interrelatedness" of environmental factors and the technological capability to make detailed, comprehensive environmental measurements, and then to integrate and interpret them in support of a host of scientific, policy, and operational uses.

Consider the following scenario.

The supertanker *EXXON Valdez* runs aground in the Gulf of Alaska. Authorities are informed of the mishap and an oil spill emergency management team is called into action to assess the situation. They call for an aerial reconnaissance of the region requesting that the airplane observations be distributed in real-time to a team of environmental experts located in various cities in the U.S. The experts determine that, based

upon the rate of spillage and spread of the oil, a major environmental disaster is in the making. The emergency management team swings into action. It assembles a panel of experts (including fisheries and wildlife biologists, oceanographers, and meteorologists) through video teleconferencing. Within minutes it determines via on-line databases the resources available in the local area to combat the oil spill including ships, personnel, and appropriate equipment. Because of the remoteness of the spill region and its areal extent, it becomes clear that satellite imaging will be essential to monitoring the situation on a broad scale, to guide the local aerial and ship reconnaissance, and to support the spill containment operations. Invoking emergency authority, the team issues a direct request to an environmental satellite to adjust its imaging schedule so as to increase the rate of data taking over the site from once per day to once every orbital overpass.

The team of scientific experts utilizes advanced high-resolution numerical models, accessible remotely at supercomputing centers, to predict the likely path of the oil spill so that spill containment and clean-up operations can be focussed to minimize environmental damage. Real-time observations of winds and ocean currents are fed to models to guide their output. The expert team accesses a remote, nationally distributed database containing the national biological inventory to determine the locations and populations of local fish spawning areas and wildlife habitats and to plan for appropriate safeguarding actions. Tha experts team devises a program of long-term monitoring to track the effects of the oil spill on the region and to assess environmental recovery. Economic models running at remote computational centers are invoked by the experts to assess the potential short-term and long-term economic impacts of fisheries degradation. Thanks to easy and timely access to real-time and historical observational data, advanced computational facilities, on-line databases, communications networks to link observing systems to emergency managers and analysts, resources have been effectively marshalled just in time to avoid serious, long-term damage to the area's environment and economy.

Such a scenario for dealing with a potential environmental disaster is technologically feasible today, but requires overcoming a set of non-technological barriers that limit the implementation of such a decision-support system.

Studies of the environment were once limited in scope to studying small regions and specific phenomena, generally in isolation from others. From the 1960s to the present, certainly our perception of the interrelatedness of environmental phenomena has changed. Equally as important, our capacity to make ever more accurate and precise regional and global measurements of the environment has expanded geometrically, particularly with the advent of advanced satellite-borne sensors as well as improved airborne, ground-based, and ocean-based instrumentation. However, our ability to fully utilize these measurements in support of decision making still lags behind our ability to make the measurements. A major cause of this lag is our inability until now to cope with the avalanche of data emanating from widely diverse systems, stored and disseminated in varied formats, and acquired in support of different agency or organizational missions. Technological solutions exist now that will allow acquisition of large volumes of disparate data, transmitting them to users, storing them in large capacity storage devices, retrieving them from databases, and manipulating them for analysis and decision support.

Environmental monitoring is primarily a federal responsibility although state and local governments also play a significant role. For example, all levels of government and the private sector participate in water resources monitoring for a total investment of several billions of dollars annually across hundreds of organizations. Federal agencies having major programs in the environmental monitoring arena include the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), Environmental Protection Agency (EPA), Department of Energy (DoE), Department of the Interior (DoI), and Department of Defense (DoD). The roles of these agencies are extremely diverse, yet complementary. Examples of the functions performed by these agencies are: daily weather forecasts and severe storm prediction (NOAA), space-based atmosphere/ocean/land science research (NASA), fossil fuel-generated pollution monitoring and assessment (EPA), nuclear dump monitoring

and nuclear power plant radiation release mitigation (DoE), characterization of the Nation's earth and water resources and public lands management (DoI), global weather and ocean prediction in support of national security operations (DoD).

The national investment in observing systems, computational systems, and telecommunications systems to support the environmental monitoring activities of the various federal agencies over the next decade runs well into the tens of billions of dollars and includes such programs as NOAA's Weather Service Modernization, NASA's Earth Observing System (EOS) Mission to Planet Earth suite of environmental satellites, USGS investment in ground water observation wells and stream gaging stations, the National Biological Survey's "Gap Analysis Project," and EPA's Environmental Monitoring and Assessment Program (EMAP).

Many of modern-day environmental issues raise fundamental questions regarding sustainable development, i.e., our capacity to maintain economic growth while preserving environmental quality. To address the range of questions requires the analysis of a vast array of information derived from globally distributed observing systems (including earth-based, airborne, ocean-based, and satellite-borne) as well as historical environmental observations and analyses contained in hundreds of disparate and geographically distributed databases and libraries. To provide the best possible decision support, whether it be to assess effects of ozone depletion, issuance of severe weather warnings, response to oil spills, or other natural or man-made phenomena, requires access both to real-time as well as to historical data and information. Advanced modeling and predictive tools, and data visualization capabilities are needed. Effective and timely environmental monitoring requires a mechanism to integrate the array of observations and analyses and to provide the means by which those needing environmental information (including scientists, policy makers, educators, the general public, etc.) are provided with the best possible information in the most timely way.

A number of barriers exist today that prevent us from fully realizing the capability to monitor the environment in a comprehensive way and to bring the information to those who can benefit.

To foster the conditions under which the national investment in technology and personnel is translated into significantly improved environmental understanding and emergency preparedness requires that a number of issues be resolved to make effective use of an advanced NII as an enabling and integrating agent for environmental monitoring and as a means by which all segments of society derive maximum benefit.

What is the Public Interest in Promoting the Application?

Environmental information is key to a broad range of individual and societal endeavors and, therefore, is a logical application for the NII. An advanced NII will be an enabler of activities that depend on environmental information including:

Economy and National Competitiveness

Businesses require environmental information to make critical decisions that directly affect their productivity and overall competitiveness. For example:

- Agricultural companies and small farming concerns require assessments of economic impacts of floods, droughts, insect infestation, and plant disease. They require environmental information to plan for planting and harvesting and to assess market needs.
- The construction industry requires ongoing assessment of regional and local environmental parameters for construction codes (e.g., to withstand earthquakes and severe vinds), insulation standards, flood plain boundaries, etc.
- Retailers require environmental information for targeting product sales for specific local climatic conditions and for timing the shipment of seasonal products for particular markets.
- The legal profession requires environmental information to arbitrate issues of culpability and liability as, for example, in the case of Hurricane Andrew property damage in South Florida.
- The insurance industry requires information to set insurance rates and to assess risks due to potential floods, earthquakes, proximity of property to hazardous materials sites, and severe storms.

- Electric power utilities use environmental information to site and design power plants, to plan for fuel consumption, and to anticipate power outages initiated by solar activity, severe storms or geologic activity.
- Consultants and other private sector companies use environmental information to develop value-added information products targeted at specific industry needs (e.g., weather and crop health information is used by consultants to advise commodities traders).

Environmental Change Assessment

It is generally recognized by the scientific community that the range of man's activities is leading to significant change in regional and global environments and, in particular, on climate. Cultural causes of environmental change include deforestation, burning of fossil fuels, and urbanization. Environmental change also results from natural causes such as volcanic activity and solar activity variations. Environmental information and the ability to accurately monitor changes over time are critical to tracking changes in biological diversity, and hence, to monitoring the health of the planet. An advanced NII can enable better and earlier assessment of trends in the earth's environment by enabling the integration of real-time observations from the myriad of observing systems and from the historical record contained in archive databases. It can enable the integration of environmental data with human dimension data to assess the effect of demographics on the environment and of the environment on demographics.

Transportation

The integration of environmental information on the NII will support the nation's transportation systems for both commercial as well as non-commercial uses. Air traffic can receive timely and more comprehensive information, marine navigation can have the latest information on hazards to navigation and on waves and currents, the trucking industry can plan deliveries around traffic delays caused by inclement weather, the general public can better factor weather into local and distant travel plans.

Emergency Preparedness and Environmental Disaster Mitigation

The integration of environmental information from a wide range of sources and its ready dissemination via the NII can allow emergency managers to access the most up-to-date and comprehensive environmental information to support rapid decision-making and contingency planning in the event of an environmental disaster. For example, in the event of toxic gas or radiation release, emergency managers could access the latest satellite observations to analyze the extent of the problem or real-time, ground-based wind measurements as well as historical wind information to assess the likelihood of such emissions reaching a designated area. Plans for evacuation, best route for evacuation, or other mitigation steps can be planned based upon such information. Support for this critical application mandates that the NII be robust, and be able to support a wide range of disaster situations. The expanding use of wireless technology can be expected to address this requirement.

Environmental Hazards Regulation and Remediation

Many thousands of sites exist in the U.S. (and many more world-wide) that contain hazardous byproducts of industrial and military activity. Many are known; many are yet to be discovered. These include dumpsites of toxic chemical and nuclear, waste most of which are on land, but a number are also known to exist at sea. Pollution standards and clean water standards are codified in federal law and are the responsibility of the federal government to monitor and enforce compliance. The NII can provide the means by which regulatory authorities, including elements of DoE and EPA, have ongoing capability to discover previously unknown waste sites, to monitor known ones, to enforce compliance with clean air and water statutes, to plan remedial action to combat pollution, and to assess the success or failure of remediation activities. This will necessitate practical, appropriate linkages among federal, state, and local authorities using the NII.

Education

Environmental information from many sources can be integrated via the NII and used to bolster the Nation's science and technology education. School teachers as well as students can be given access to both real-time and historical data to explore real-world natural phenomena. The government's volumes of science and technology information can provide excellent source material for teachers to build lesson plans, to become more knowledgeable in a particular subject area, and to develop materials for class presentation. Likewise, an ability to monitor natural phenomena such as earthquakes, volcanic eruptions, and severe storm events in a classroom environment as they happen can form an invaluable experiential learning tool. The following application is proposed as part of the Vice President's Global Learning and Observations to Benefit the Environment Program. The participation of school children across the globe can be incorporated in a real scientific experiment. Schools will be issued devices such as the commonly available personal digital assistants (PDAs). They will be asked to take periodic environmental measurements such as air temperature and then to transmit the readings to a central repository using their PDA. The information will be incorporated in a scientific analysis with feedback of results provided electronically.

Natural Resource Management

Effective policy making with regard to natural resource utilization and its impacts on our economy and the economies of other nations depends upon natural resource utilization planning, and assessments of the effects of utilization on regional and global environments. Quality of life considerations require ongoing cognizance of natural resource inventories and the impacts of utilization. For example, a major environmental concern today is the effect of deforestation, and particularly loss of the earth's tropical rain forests, on regional and global climate. Such potential environmental change has immeasurable impacts on economic and global habitability considerations. The NII has the potential to bring together widely diverse information from environmental observing systems and historical information repositories that, when integrated, provide the guidance needed to manage such natural resources and to predict deleterious effects.

How Do We Know Whether We Have Succeeded?

The positive effects of the NII environmental monitoring applications will be measured in ways we cannot fully predict at this time. However, the evidence of our success will be apparent over time and will be measured in terms of:

- Reduction in time to assemble environmental information for emergency action in the event of natural or man-made environmental disaster.
- Ability to locate and retrieve comprehensive, up to date, critical data for economic analysis and environmental policy considerations.
- Improvement in the quality of environmental research results attributable to easy access to multiple agency databases.
- Enhancement in executing the government's regulatory role in pollution control and natural resource utilization.

Better, more reliable information and access to such information by analysts, scientists, policy makers and the general public will put an end to the perceived conflict between the economy and the environment; the Nation will get more results for its enormous annual investment in environmental observation and protection.

PART II: Where Are We Now?

Environmental monitoring is an activity that is primarily the purview of the federal government. However, significant participation exists in academia and private industry in the form of research to advance environmental understanding, to develop the technologies for observing the environment, and to provide value-added information products.

Even with the limitations of today's information infrastructure, there are some good examples of the power inherent in environmental collection and dissemination. For example, the Emergency Planning and Community Right to Know Act of 1986 established a Toxic Chemical Release Inventory, which requires industries to report their estimated total releases of toxic chemicals into the environment. Able to access the information via an innovative online service called RTK Net,

citizens were able to point to the harms and urge polluting companies to reduce their emissions. Based on public pressure and their own concern about the quantities released, many companies voluntarily committed to making major reductions, even though no regulation mandated reductions. This demonstrates how publicly-assessable and usable environmental can wield tremendous power, both in the economic marketplace and the marketplace of public opinion.

Federal agencies with major activities in this arena include (but are not limited to) NOAA, NASA, DoI, DoE, EPA, DoD, and U.S. Department of Agriculture (USDA). Some existing federal programs and interagency activities provide both the impetus to move forward and a base of experience in interagency cooperation in the environmental arena.

Some Major Interagency Efforts

U.S. Global Change Research Program

The USGCRP is a multi-billion dollar federal program that involves most of the U.S. agencies with environmental programs as well as some that do not. It also includes academia and private sector. This program consists of research activities that involve deployment of a number new environmental observing systems including the EOS satellites (scheduled for launch beginning in 1998), implementation of networks and data processing centers to support data acquisition and distribution, and a range of scholarly research. The networking part of this program is embodied in the Global Change Data and Information System (GCDIS), which is intended to provide the appropriate level of communications technology, interoperability, and connectivity to allow easy exchange of data among participating agencies.

Global Change Data and Information System

The U.S. Global Change Data and Information Management Plan, a Report by the Committee on Earth and Environmental Sciences approved in 1992, commits the participating Federal agencies to work with each other, with academia, and with the international community to make it as easy as possible for researchers and others to access and use global change data and information. Toward this end, the agencies are organizing a Global Change Data and Information System, which takes advantage of the mission resources and responsibilities of each agency.

The GCDIS is described as the set of individual agency data and information systems supplemented by a layer of crosscutting new infrastructure, and made interoperable by use of standards, common approaches, technology sharing, and data policy coordination. Current plans call for the development of network interconnectivity, interagency data gateways, adoption of common standards for data exchange, and the establishment of procedures and policies for data and information dissemination among the participating agencies. As a decentralized system, the primary focus of the GCDIS is on establishing and maintaining effective mechanisms that integrate the disparate elements.

National Spatial Data Infrastructure

The Federal Geographic Data Committee (FGDC), established by OMB Circular A-16, has as its goal the creation of a national digital geographic information resource. The importance of this committee has significantly increased under the chairmanship of Interior Secretary Bruce Babbitt, and implementation of the National Spatial Data Infrastructure (NSDI) by Executive Order is anticipated. The FGDC has taken a lead role in the development of data exchange and metadata standards needed to implement the NSDI. The scope of the NSDI includes all types of geographic information system (GIS) data from mapping and charting to all geographic or "spatial" data including climatic, demographic, natural resource, oceanographic, and geophysical data.

High Performance Computing and Communications Program

The U.S. federal HPCC program is a major multi-billion dollar interagency activity designed to promote the development of technologies and applications in high-performance computing and in telecommunications. Several agencies with major environmental programs are players in this program. A major element of the Program is the development of the National Research and

Education Network (NREN), which would expand current Internet capabilities with a much higher capacity network. In 1993 a major new element, referred to as Information Infrastructure Technology and Applications (IITA) was incorporated in the program to advance the use HPCC technologies in the development of the NII. Environmental Monitoring is one of approximately eight applications that define and establish technical requirements for implementing advanced telecommunications systems and services under IITA. The NII is seen as an integrating element and facilitator in Environmental Monitoring applications; that is, it promises to provide the transport mechanism and the data translation services to allow the user to work with many heterogeneous databases that are geographically dispersed.

Federal Agency Activities

Natıonal Oceanic and Atmospheric Administration

NOAA has mission responsibility to predict the weather, chart the seas, assess natural and man-induced climate change, manage U.S. fisheries, and perform environmental research to advance capabilities in these areas. NOAA is a major participant in the U.S. Global Change Research Program (USGCRP), within which it performs basic ocean and atmospheric science research as well as conducting research in a variety of environmental areas within its laboratories. It also participates in major international and interagency environmental research activities including the World Ocean Circulation Experiment (WOE), Joint Global Ocean Flux Study (JGOFS), and the Global Energy and Water Cycle Experiment (GEWEX) Continental-Scale International Project (GCIP). In carrying out its mission, the agency operates a variety of observing systems including environmental satellites, doppler weather radar, ground-based weather sensors, ocean-going fleet, ocean-based instruments, etc.; telecommunications facilities have been established to support the acquisition of data from these observing systems for operational use. The agency operates three National Data Centers (National Climatic Data Center, National Oceanographic Data Center, and the National Geophysical Data Center) charged with maintaining the nation's climate, ocean, and other earth science records and distributing environmental information in support of commerce, transportation, construction, education, research, etc.

NOAA's High Performance Computing and Communications (HPCC) Program has been established to coordinate the agency's needs for and development of high performance computation in support of mission objectives and the fundamental telecommunications infrastructure for environmental information acquisition and dissemination internally and with the outside. NOAA's Environmental Service Data and Information Management (ESDIM) Program provides coordination within the agency and with outside organizations (including federal, international and academic institutions) in matters of environmental information management, including environmental information product generation, distribution, and standards; data policy considerations; and interagency and international agreements on environmental data exchange.

National Aeronautics and Space Administration

NASA has mission responsibility to conduct space-based research in atmospheric, ocean, and land science and the development of satellite-borne sensors to accomplish this research. In support of this mission, NASA has long been involved in the development of information systems to acquire the data from these sensors, manage it, and convey the data to its researchers. It is currently involved in several major interagency and international environmental research programs including USGCRP and GCIP.

NASA has undertaken an ambitious program to launch a series of earth observing satellites beginning in 1998 referred to as the Earth Observing System (EOS). These satellites will measure a variety of atmospheric, ocean, and land parameters over a period of 15 years to arrive at a better and more comprehensive understanding of earth processes. In particular, the measurements will attempt to provide answers to fundamental questions about how the earth's environment is changing.

An equally ambitious program of data management, called the EOS Data and Information System (EOSDIS), has been established to develop the systems to acquire, manage, and

disseminate the environmental data from the satellites. A set of eight Distributed Active Archive Centers (DAAC) have been established by NASA along scientific discipline lines to receive the data, generate information products, and distribute them to NASA's research community. These DAACs will be interconnected via a high-bandwidth telecommunications infrastructure called the NASA Science Internet (NSI) to enable data exchange among the DAACs.

NASA has initiated a program on Public Use of Earth and Space Science Data Over the Internet by developing pilot end-user remote sensing database applications and applying new digital library technologies that can enable and demonstrate the application and accessibility of earth and space science databases. Remote sensing database applications potential areas of interest include: atmospheric, oceanic, and land monitoring; publishing; agriculture; forestry; transportation; aquaculture; mineral exploration; land-use planning; libraries; cartography; education (especially K-12); entertainment; environmental hazards monitoring; and space science data applications. Potential Digital Library technologies include: innovative user interfaces; direct public access to satellite imagery; heterogeneous databases; information retrieval; advanced search and browse techniques; data structures; use of data and image compression; distributed database systems; accounting and data security; file storage management systems; and resource discovery.

Environmental Protection Agency

EPA is responsible, through its research and regulatory authorities, for protecting public health and ecological resources from environmental pollution. Environmental monitoring is an essential tool in the development and evaluation of policies intended to protect human and ecological health. The use of environmental monitoring data allow EPA offices and their partners to better estimate the risks associated with pollution in the environment and to more effectively manage these risks. Specifically, EPA's environmental monitoring and research activities relate to the development and field evaluation of models that: 1) estimate concentrations of pollutants in the environment based on source information and 2) evaluate the risks posed by these pollutants to human and ecological health.

These efforts are supported by programs that develop methods and technologies for measuring pollutants in the environment and approaches for assuring the quality of monitoring data.

EPA also monitors pollutant concentration and indicators of human health and ecological condition as a means of evaluating the effectiveness of its policies and regulatory decisions. These efforts include: 1) several Clean Air Act-mandated programs to monitor concentrations of the major ambient air pollutants and their sources; 2) monitoring of water supplies and discharges into lakes and rivers mandated under the Clean Water Act; 3) the Environmental Monitoring and Assessment Program (EMAP), a national scale program to monitor ecological resources; and 4) the National Human Exposure Assessment Survey (NHEXAS).

EPA's environmental monitoring programs allow the agency to continuously evaluate and improve its regulations, decisions, and policies, by ensuring that all relevant scientific and technology information is considered in their development. EPA provides information and data to the public and other interested stakeholders through a variety of means: public information centers, limited mainframe access, electronic bulletin boards, hotlines and clearinghouses. Key environmental systems that are of interest and importance to the public and businesses are available such as the Toxic Release Inventory (TRI). Also, the Center for Environmental Research Information is the focal point for the exchange of scientific and technical environmental information produced by EPA.

Department of Energy

DoE has mission responsibility to provide an environmentally safe, economically sound, and politically stable energy future. It conducts focussed scientific research involving the carbon cycle including research on the effects of fossil-fuel emissions on the earth's biosphere. To support its research efforts and its data dissemination, DOE has established the ESnet wide area network connecting 23 sites and with links to the Internet.

DoE has significant expertise and experience in using computing and information technology to support its efforts in environmental cleanup. Databases currently exist for classification of waste streams and waste tank status and condition. DoE is pioneering the effort to develop and use Geographic Information Systems (GIS) in the process of monitoring and managing environmental remediation. The agency is a leader in the development and use of modeling and simulation technology for modeling groundwater flow and evaluating the effectiveness of remediation technology. DoE also has developed leading edge technology in robotics and teleoperated systems.

DoE's overall objective is to leverage the large, ongoing investment made by industry and other government agencies in the successful implementation of the NII dedicated to enhancing the quality of our environment. Both managing and remediating existing waste sources and reducing waste from U.S. manufacturing operations through universal access to best practices information are critical. DoE will apply its information infrastructure resources to ensure that an information structure is developed and implemented providing significant utility to all enterprises in the Environmental Restoration Industry to enhance their productivity and competitiveness by:

- Reducing the time required for the industry to identify, characterize, assess, recommend and remediate environmental issues
- Providing and enhancing the access for all environmental industry enterprises to the intimidating amount of regulatory information in a timely manner
- Ensuring high performance access to resources, especially monitoring and modeling resources, to validate remediation plans.

DoE makes environmental information available through three major centers: the Carbon Dioxide Information Analysis Center (CDIAC), the Energy Information Administration (EIA), and the Office of Scientific and Technical Information (OSTI). CDIAC is focussed on deriving information for global change analysis and is the nation's primary steward of information on greenhouse gases. EIA has data collection and analysis authority for total fuel cycle especially for benefit-cost analysis of environmental impacts. The data holdings are a resource for energy production and/or use and socioeconomic analysis. OSTI is responsible for managing the department's scientific and technical information, particularly it's scientific publications.

DoE researchers located at several National Laboratories are involved in major interagency and international environmental research programs. These include the U.S.GCRP, WOE, and JGOFS. A major new research program in DoE, the Atmospheric Radiation Measurement Program acquires and analyses the environmental data necessary to characterize the climate-cloud mechanisms for understanding climate change.

Department of Interior

As the major federal land manager and a primary federal agency responsible for managing the Nation's natural ecosystems, fish and wildlife, and energy and water resources, DoI is particularly concerned with environmental monitoring. DoI's programs address topics such as the quantity and quality of the Nation's freshwater resources; geologic processes (including earthquakes) and earth resources; land use, and land cover; biological habitats, resources, and diversity; past environmental change recorded in the physical, chemical, and biological record; land surface and solid-earth processes that relate to environmental change; geography and cartography; polar and arid region processes; ecosystem modeling and dynamics; and resource ethnology. DoI bureaus collect, maintain, analyze, interpret and actively maintain short- and long-term land, water, air, biological, and other natural resource data and information in support of their missions. These efforts require the maintenance and communication of many levels of data and information, whether remotely sensed or gathered in situ, and extensive collaboration across many organizational and technical barriers, nationally and internationally.

PART III: Where Do We Want to Be?

What is envisioned for the environmental monitoring application area of the NII is a virtual national monitoring system that brings together

data sources and data users, integrating existing systems and building upon their strengths. In addition to providing the integration mechanism for the disparate components of U.S. environmental monitoring infrastructure, such a system should have strong links to international observing systems and environmental data centers so that a truly global environmental picture can be assembled. Developing the environmental monitoring application does not mean replacing the existing systems used by various organizations for fulfilling their missions, but rather developing the layer of hardware/software linked via telecommunications facilities providing appropriate transmission capacity and network services.

A national environmental monitoring infrastructure should allow the various participating organizations (both public and private) to continue to pursue their individual independent missions while harmonizing their activities with other organizations. It is impossible to quantify the synergy accomplished given the implementation of the infrastructure, but it is very clear that comprehensive environmental management cannot occur without it.

PART IV: How Are We Going to Get There?

To achieve the goal of a national integrated system for environmental information and services using NII enabling technology requires a commitment on the part of federal agencies to coordinate development and implementation. Plans that currently call for agency-specific development should be reconsidered in light of the need to satisfy larger national goals. Leadership on the part of the federal government is required to foster partnerships among public and private organizations so that each sees a clear benefit in participation and cooperation.

We should note that the federal government is providing strategic leadership, e.g., the data management principles, OMB Circular A-130, Federal Information Processing Standards (FIPS), the NII Agenda for Action, the Government Information Locator Service proposal, the National Environmental Index, and the National Spatial Data Infrastructure plan. The federal government is also helping to development promote many of the critically important technologies and technical standards (e.g., the Internet, the Spatial Data Transfer Standard, the ANSI Z39.50 Information Search and Retrieval Standard).

The federal government should commit to providing the organizing principles for the comprehensive framework that underlies environmental information, and should actively promote the consolidated acquisition and other sharing of data, as is done with the National Aerial Photography Program. The federal government should also promote consensus building using electronic mechanisms.

Making it happen will require close attention to eliminating some barriers. The following are some of the areas on which we must focus:

Interoperability Standards

Interoperability may be the single most important issue in realizing the integration of environmental information on the NII; without agreement on interoperability standards and a commitment to adhere to these, we are left with the current set of disparate and isolated environmental information systems. Multidisciplinary analysis, critical to addressing environmental concerns, will be nearly impossible and will proceed at the slow pace that it currently takes by necessity. Environmental observations may be single measurements at one location, time series at a location, digital imagery of the entire planet, swaths of observations of the earth's surface, profiles through the atmosphere, etc. The data types may be text information, or numerical values, graphics products, or digital imagery. The size of environmental data sets may range from single-point measurements to hundreds of terabytes. A proliferation of data formats currently exists to support the myriad of data types. For environmental data to be transported from various observing systems owned and operated by a variety of agencies, integrated into information products, and distributed to the appropriate user on the NII, a set of data formats and electronic information exchange protocols must be universally adopted.

Interoperability also implies the existence of user interfaces that are intuitive and common across the various environmental databases. However, the valid integration of information presents fundamental problems of data consistency that must be addressed by the development and application of content and metadata standards. The user should be capable of formulating questions and receiving responses without having to be knowledgeable about how each system is organized.

Information Security and Reliability

To maintain user confidence in environmental information on the NII, appropriate measures must be taken to preserve the integrity and reliability of data. Any system deployed for information dissemination must incorporate the appropriate safeguards to ensure against the intentional or unintentional corruption of the information. Further, uniform quality standards must be adopted and enforced that ensure that data derived from a number of sources and integrated into information products that are then used by policy makers, scientists, educators or the general public are of consistent high quality regardless of source. The environmental monitoring information must be highly reliable not only in terms of quality but also in terms of timeliness to maintain the confidence of those segments of society who rely on the information for routine forecast purposes, issuing emergency natural hazard warnings, recreation, or in conducting day to day activities.

Very Large Data Volumes

Planned or currently deployed environmental observing systems, both satellite- and earth-based systems, produce data at ever-increasing rates as the observing technologies extend the spatial, temporal, and spectral coverage of measurements. Some systems are capable of producing hundreds or gigabytes of data daily with much of the transmissions being "bursty" in nature, i.e., large volumes in a short time period. Further, the accumulated databases may range into the hundreds of terabytes. The NII must provide the end-to-end transmission capacity as well as a means of prioritizing transmissions to ensure that data needed for environmental monitoring are available when required by the user. The bandwidth and prioritization consideration are particularly important for real-time environmental data acquisition necessary to protect life and property.

Information Access/Connectivity (including international)

A definition of levels of access and connectivity must be agreed upon. In many cases, a simple modem and data terminal are all that is required for access to environmental information; in other cases, equipment and connectivity to support virtual reality environments are necessary. A hierarchy of network functions must be defined with the appropriate communications services and technologies. A "floor" or fundamental set of network services available to nearly everyone must be defined and goals should be established on the time frames for providing the fundamental services and the higher service levels. Since environmental issues recognize no national boundaries, the two-way free flow of environmental information must be maintained with other nations who are both consumers of U.S. data as well as producers of data for U.S. consumption.

For environmental monitoring considerations, the NII must be sufficiently robust and dependable to provide the transmission medium for data that affect protection of life and property. The data from environmental observing systems must be reliably transported to organizations responsible for emergency preparedness. The information products, including forecasts, warnings, or emergency bulletins, must be reliably transported to the intended target and in a timely way.

Exploiting Multiple Uses of Acquired and Processed Environmental Data

Environmental data normally have many important uses beyond the primary purpose for which they are acquired. For example, wind measurements may serve the primary purpose of short-term weather forecasting but find important other uses in long-term climate assessment, siting power plants, building design, etc. A variety of agencies are responsible for various environmental observations specific to fulfilling the agency's mission; more often than not, the data are not fully utilized for other purposes and are not integrated with other-agency data because of difficulty of access, lack of adequate documentation, etc. The NII may serve as an integrating medium leading to the sharing of environmental information to provide more comprehensive data sets and improved monitoring.

Issues and Questions to Be Addressed

The following issues and questions need to be addressed and policies initiated to facilitate the development of the environmental monitoring application as part of the NII. It should be noted

that these issues, in and of themselves, will *not* ensure overcoming the barriers described in the previous section of this paper; but they are a starting point. Full realization of a national environmental monitoring system enabled through the NII will require tackling a full range of issues discussed in this paper.

- A Global Change Data and Information System (GCDIS) is the cornerstone for collection and dissemination of global change and other environmental data and information for use by the private sector, researchers, educators and others. The importance of this activity must be recognized within the National Science and Technology Council (NSTC) process. How should the NSTC Committee on Environmental and Natural Resource Research, with support from the Committee on Information and Communications pursue the full development of a GCDIS that fully satisfies a wide range of public and private information requirements? What actions are required to ensure that all involved federal agencies are appropriately funded?
- Several federal agencies are conducting research into systems to handle environmental information. Coordination is required and the effort needs to be expanded to ensure that national needs are met. How should the HPCC Program, through its IITA component, establish a set of environmental information dissemination pilots to stimulate development and test application of new network information navigation and access tools, such as extensions of MOSAIC, that focus on access to very large amounts of heterogeneous environmental information distributed across agencies in many geographical locations?
- There is currently no generally accepted methodology or data format to allow easy exchange of data from one agency's system to another and, therefore, a user cannot easily navigate through thousands of environmental databases of the agencies. How should the Federal Geographic Data Committee move forward as directed in the National Performance Review in establishing a National Spatial Data Infrastructure in developing the consensus among federal and private concerns for standards and technologies to facilitate spatial data exchange? How should NOAA take the lead, in response the Executive Order, to coordinate with other federal agencies the development of the National Environmental Index establishing the information content and format standards for cataloging environmental data? How should NIST work proactively with agencies involved in environmental monitoring to ensure the appropriate application of federal systems and information standards?
- A very large number of agencies distribute environmental data in electronic form, some of which is fee-based. Currently many agencies (and many sub-agency units) manage billing and accounting services separately, although some use the services of the FedWorld gateway run by the National Technical Information Service (NTIS) in the Department of Commerce. In many cases, users must make separate payment arrangements with each database distributor. How can the NTIS or other billing and accounting services be accessible to all government information providers? How can users negotiate costs and billing with a single organization and receive a single bill?

Libraries and the NII

DRAFT FOR PUBLIC COMMENT

Policymakers must determine how to sustain, in the electronic age, the democratic and equal access to information that free public libraries have provided in the age of print.[1]

PART I: What Is the Application Arena?

Description of Libraries

The Traditional Role of Libraries. Libraries are central to the storage and sharing of knowledge, history, and culture. They offer access to knowledge and information representing diverse sources and viewpoints. Libraries are adjuncts to education, a base for generating innovative thinking, a stimulus to culture, and an aid to the individual self-development of citizens. They are also keepers of the intellectual, cultural, and historical memory of their community. Libraries acquire, catalog, make available, and preserve collections in all media. These collections traditionally consist of material items stored in site-specific facilities which limit access to those who can travel to the site of that library or receive the items through interlibrary loan. Whenever an item is in use, it is temporarily unavailable to all other people.

Libraries have developed in response to the nature and character of the publishing communities. In the United States, libraries have served as information "equalizers" or providers of equal access for all, permitted by the first sale[2] doctrine of copyright law to lend copies of copyrighted works after their initial distribution.

The Role of Libraries in the NII. The ability of digital libraries to store and share knowledge, history, and culture will be central to the success of the NII. The digital library[3] is really a library with extensive electronic collections in a variety of forms in different locations. Increasingly materials are being acquired in electronic form; libraries are beginning to convert their paper and analog collections to machine-readable formats for both preservation and spatial reasons.

As today, the role of libraries in the future will be to advocate and help provide information equity for the public. Libraries will continue to coordinate and facilitate preservation of the records and expressions of the nation's intellectual and cultural life both in traditional and digital formats. Libraries will be sources of free or inexpensive digital information; provide access to an improved flow of electronic government information

[1] Statement by James H. Billington, the Librarian of Congress, at the "Delivering Electronic Information in a Knowledge-Based Democracy" (DEIKBD) conference; proceedings, 4.

[2] The first sale doctrine of copyright is the information equalizer in that it limits copyright owners' rights by making only the initial distribution of a particular copy of a work subject to the owner's control. Section 108 of the copyright code allows libraries to make copies of certain works under certain conditions both for patrons and other libraries.

[3] "Digital library" is used here as an aggregate, implying electronic access to many sources of digital information. This includes libraries but does not exclude other sources such as corporate, government, and research entities.

and world-wide digitized resources; request and be sent copies of remotely stored documents and other publications as allowed by copyright licensing and other agreements; make digitized reproductions of rare and unique material that is in the public domain or for which permission of the copyright owner is available as allowed under the copyright law; and provide long-term access to the records and expressions of culture and scholarship.

The evolving information infrastructure is already dramatically changing traditional operations within and relationships among libraries and their providers and users. It is also offering new challenges. New forms of unpublished, and often unauthenticated, digitized materials are emerging as millions of people are linked by world-wide networks. The volume of new digital material, if it were on paper, would eventually dwarf the existing physical collections. The situation is additionally complex because digitized information can be easily updated, manipulated, and combined with other materials, and displayed in multiple ways. Digital data thus creates enormous new amounts of knowledge that may be accessed and manipulated by computers, existing temporarily and never stored anywhere permanently. Institutions, including libraries, may provide access to these materials without ever physically controlling them, and readers at multiple sites have access to the same material at the same time.

Future Role of Librarians. The role of librarians will change significantly as they become increasingly viewed as managers of both information and knowledge. This forward-looking perspective was underscored at the Library of Congress (LOC) conference on "Delivering Electronic Information in a Knowledge-Based Democracy" [proceedings, 5]. These knowledge management skills may take many forms and can be expected to involve librarians in all facets of the information chain. Librarians may be present at the information generation process; they will help manage digital materials and assist people in dealing with the plethora of information. Librarians will increasingly function as facilitators, enablers, and teachers of network users; library systems and consortia will negotiate information access rights[4] on behalf of public users of the digital library. Librarians will become guides to network tools in much the same way as they have acted as guides to the use of traditional materials.

New Roles and Alliances. New roles and alliances are expected to emerge. The originators of published and unpublished information are being empowered by the new digital information tools to carry out many of the services previously fulfilled by libraries: from subject-driven information delivery to navigational services and from onsite access to virtual access as providers of research tools. This could expand the concept of "libraries" to include not only collections maintained by traditional libraries but also those held by publishers, research organizations, universities, commercial enterprises, and new players of all kinds.

While the digital library within the context of the NII is a national initiative, there are significant international implications both for the sharing of information across national borders and for the shift in the organization of intellectual creativity. Questions of international cooperation and economic competition will arise. Because the infrastructure permits international access to digital information in a way that is impossible in the traditional library model, new international relationships and models can and will emerge.

Without taking into account from the outset rules for effective protection of intellectual property, the development of an international system (the Global Information Infrastructure (GII)) will be severely hindered. In a global system a user in

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[4] "Access" implies a complex of possibilities. It includes online viewing either by one or many users, printing, downloading, transmitting the work to ther libraries, modem access, public performance, and public display. This list while not all-inconclusive does suggest the complexity of the access issue which must be addressed by copyright law as well as by vision and technology. To paraphrase Barbara Ringer's statement at the Senate Committee on Rules and Administration Hearing on March 3, 1994: It is obvious that we are at the beginning of an enormous revolution in communications. What isn't obvious is that the copyright law is at the center of this revolution and will determine the course it takes. The bulk of the material to be transmitted on the superhighway is copyrighted, it is intellectual property that is owned by someone.

BEST COPY AVAILABLE

one country will be able to manipulate information resources in another country in ways that may violate that country's copyright laws. Copyright laws are territorial; international copyright conventions and other multilateral agreements allow for significant differences in national laws. Work must begin on international harmonization of copyright laws to accommodate a digital world.

The Application. Digital libraries in the NII will contain vast amounts of digitized data: text, pictures, audio, and video. The data will not be located at any single site, but rather will consist of digitized materials and processing methods from many sources. The development of digital collections in libraries will depend on the following components:

- **Interconnected and Interoperable Networks.** Digital libraries are premised on the existence of a network of networks, interconnected and interoperable.

- **Decentralized Data and Processing.** A second assumption concerning the digital library is that information and knowledge can exist and processing can take place at multiple, decentralized sites.

- **Databases.** Digital libraries will contain data that only exists digitally and digitized data that has been converted from another medium such as print, sound, or audio. Developing techniques to consistently collect, store, and archive digital material using automated methods is an important first task for the digital library community. The conversion of existing material to digital form also is important. This converted material will form the nucleus of the digital database and provide a bridge to traditional collections.

- **Navigation and Retrieval Tools.** Navigation and retrieval tools capable of identifying, accessing, and retrieving the digital resources must be developed. When practical, major navigation and retrieval tools will be based on standards that ensure the ability to communicate in order to share both data and processing.

- **Document Delivery.** The ability to deliver physical copies in print or in any of several fixed digital formats must be supported.[5]

- **Presentation.** Presentation standards and techniques to assure reliable and effective representation of intellectual content must be created.

- **Mass Storage.** The ability to store increasing amounts of data at steadily decreasing costs is a technological trend that is vital to the massive amounts of data that digital libraries will need to store and support.

- **Human Resources.** The most critical success factor for the success of digital libraries will be the human resources component. This component assumes the education of a new generation of librarians as knowledge navigators; training and retraining of current librarians; and training of the public in the new technology and the use of electronic information resources.

Benefits of Applications in This Arena

The benefits of linked digital libraries include continued and expanded access to current information and access to historical material in unparalleled detail. Technical barriers to information sharing will largely disappear. Using libraries as gateways to the digital network can help ensure that information is accessible to all and prevent the formation of a society divided into information haves and "have-nots." Libraries must continue to play their vital role of information safety net for the public by providing access to and promoting literacy of digital materials much as they have for printed materials. This is particularly true of libraries' role in providing access to and navigation of the plethora of government information that is to be made available electronically.

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[5] Document delivery, while a technical component of the applications, involves significant copyright issues that must be resolved. Downloading substantial amounts of copyrighted material will require license agreements with related questions of who will pay and how will they be administered. Guidelines must be developed as to what are insubstantial amounts of downloaded materials, subject to fair use exemptions.

As Senator Edward Kennedy recently stated [quoted in McClure et al, 38]:

> Public libraries are a vital information link between the government and the public...libraries must continue to play a critical role in providing broad access to the public...[and guiding] citizens of all ages through the world of computer networks...[L]ibraries will make the government less remote and more responsive to the needs of individual citizens.

Measures of Success of Digital Libraries

An important measure of library success is use. An example of this is LOCIS, the Library of Congress Online System, that was made available via the Internet in April 1993. While Internet LOCIS was only available for 8 months of fiscal year 1993, Internet transactions accounted for 6 percent of the total number of LOC mainframe computer transactions in 1993. It is projected that Internet transactions will account for more than 12 percent of the total number of mainframe transactions in fiscal year 1994. Rising usage statistics and positive public response demonstrate that Internet access to LOCIS is a success. The same type of measurement must be applied to the digital environment. When there is substantial use of electronic information, particularly of items not otherwise available, then success that can be measured has been achieved.

Other indicators of success of digital libraries are changes of patterns of patron service and demands. If patrons indicate a preference for digital forms, then this new form of material is a success. This has already happened in large part for library catalogs.

Some indirect measures of success include decreased costs of processing, managing, and storing materials and increased availability of resources.

PART II: Where Are We Now?

Libraries

Demographics. There are 87,000 public and private school libraries, 9,000 local public libraries, 4,600 college and university libraries, plus hundreds of specialized business libraries and federal and state libraries in American today. More than 182,000 professionals work in libraries [Billington, 109].

Connectivity. Based on the preliminary results of a national survey of public libraries sponsored by the National Commission on Libraries and Information Science (NCLIS) and executed by Professors Chuck McClure (Syracuse) and Doug Zweizig (Wisconsin-Madison), approximately 21.1 percent of the responding libraries are currently connected to the Internet and 78.9 percent are not. However, 84.6 percent of the responding public libraries serving populations of 500,000 or more are connected, while only 13.3 percent of the libraries serving populations of less than 5,000 have Internet connectivity.

Of the 1,400 depository libraries, 929 (68.1 percent) have access to email via Internet, Bitnet, or other electronic service; 716 (52.5 percent) depository libraries have file transfer; a survey question concerning telnet or remote database access capability was not included in the survey [US/GPO].

Government Applications

Several federal agencies of importance to libraries have been mandated to develop applications using the NII. The applications have involved electronic publishing and conversion, navigation and retrieval tools, interoperability standards for information transfer between different networks or different hardware and software systems with reliability and accuracy, copyright management in an electronic environment, and archival efforts. Of the programs cited, the Government Printing Office (GPO) Access Act and the National Telecommunication and Information Administration (NTIA) Grants program support operations. All of the other programs noted are research and development (R&D) efforts. Some agencies, recognizing the potential of networked information, have begun network efforts as part of improving existing services. These are listed under Operational Efforts.[6]

[6] Most government funding of the NII to date has supported R&D rather than operations. The notable exception is the funding for the telecommunications backbone funded through the NSF which connects the regionals.

Government R&D and operational programs of note are:

Research and Development.

■ **High Performance Computing and Communications Research and Development.** The Federal High Performance Computing and Communications (HPCC) Program provides funding for research in library and information science and systems required to advance the development of digital libraries. NSF, ARPA, the Department of Energy, the National Aeronautics and Space Administration (NASA) and others participating in the HPCC Program are funding a variety of projects to support the creation of digital libraries and advance the technology base available to operate digital libraries. Under a new program component, Information Infrastructure Technology and Applications, ARPA funds the development of hypermedia systems with intelligent human interfaces; NSF funds digital libraries research; NASA is developing prototype digital libraries and advanced methods for accessing their data; the National Institutes of Health are developing advanced medical database technology; the National Security Agency supports research in mass storage and database management; and the Environmental Protection Agency and the National Oceanic and Atmospheric Administration are expanding access to environmental data.

■ **Research on Digital Libraries.** HPCC R&D includes cooperative initiatives, combining agency funds and efforts. A recent endeavor of importance to libraries is the Research on Digital Libraries Initiative, a joint effort of NSF, ARPA, and NASA. This initiative provides grants for research on systems for data capture, software for searching, filtering, and summarizing large volumes of data in various formats, and networking protocols and standards that can accommodate the high volume and bandwidth requirements of digital libraries.

■ **Other.** R&D projects such as the Digital Technical Reports Library project involving ARPA and other players, and the NSF Digital Library Initiative, have emphasized the manipulation of large data collections, including models for policy and technology tools necessary to make large amounts of data available. The use of sophisticated text retrieval techniques, including statistical and semantic analysis, continues to be explored through activities such as the Tipster project and the Text Retrieval Conference (TREC), both sponsored by ARPA. ARPA also is providing support for the CS-TR (Computer Science Technical Reports) R&D project. This is an effort to share university-generated computer science literature in a linked digital library among the participants (MIT, UC-Berkeley, Carnegie-Mellon, Cornell, and Stanford). The overall project is coordinated by the Corporation for National Research Initiatives (CNRI).

Operational Efforts. The GPO Access Act of 1993 encourages electronic availability of federal information. The NTIA Grants is intended to stimulate the building of the infrastructure. Due to demand and perceived value, some agencies are striving to make use of the Internet to make data available electronically. Some federal databases are only available through private sector vendors, and several of the most important of these are candidates for low-cost distribution to the public (for example, the Security and Exchange Commission's EDGAR database). Several dozen federal agencies already provide points for distribution of publications and other agency-generated information on the Internet. Other efforts include the management and distribution of copyright information pilot and federal preservation and archiving projects.

■ **GPO Access.** The Government Printing Office "Access" Act, which became public law in June 1993, requires the Superintendent of Documents to maintain an electronic directory of federal electronic information; provide a system of online access to the *Congressional Record*, the *Federal Register*, and other appropriate publications; and operate an electronic storage facility for federal electronic information. These services are to be operational by June 1994. Depository libraries are to have free access to the services while others will pay a fee to cover the incremental cost of dissemination. The law also requires the Superintendent of Documents to accommodate, to the extent practical, agency requests to include their information in the GPO online access system.

■ **NTIA.** P.L. 103-121, appropriating FY 1994 funds for the Departments of Commerce, Justice, State, the Judiciary, and related agencies,

includes $26 million requested by the Administration to begin an information infrastructure grants program to support demonstrations of new telecommunications technology applications. Libraries are among the institutions eligible to receive matching grants under this program to expand telecommunications networks and to access existing and new sources of electronic information.

■ **Federal Information Online.** Use of electronic bulletin boards systems (BBS) and online databases has grown rapidly within the government over the past decade. More than 40 organizations within the federal government operate BBS as part of their information dissemination activities. These BBS can be accessed directly through a modem, and, in some cases, through the Internet. The Fedworld BBS, operated by the National Technical Information Service (NTIS), provides easy access to a plethora of government information sites, including digital libraries, more than 130 other federal BBS, and digital documents such as Presidential speeches and health care legislation. The White House routinely posts the text of speeches, press briefings, press releases, reports, and legislative proposals to various bulletin board systems, including some available through consumer-oriented services like Compuserve and America On-line. A few members of Congress have begun posting the text of their speeches and press releases to publicly accessible bulletin board systems; one member has set up a Gopher server. Several dozen federal agencies provide Internet distribution of publications and other agency-generated information through public Gopher, World-Wide Web (WWW), Wide Area Information Server (WAIS), and other servers or File Transfer Protocol (FTP) sites.

■ **Publishing and Data Creation.** More than 50 separate organizations within the federal government were listed as database producers in a 1992 directory of online databases. Among the 175 publicly available federal databases, perhaps the best known are the National Library of Medicine's MEDLARS system, the National Agricultural Library's AGRICOLA system, the Library of Congress information system LOCIS, and the Federal Election Commission's Direct Access system.

■ **Electronic Copyright Management System (ECMS).** ARPA, the Library of Congress, and CNRI are collaborating on the development of an experimental Electronic Copyright Management System to explore the use of high-performance computing systems and networks, tools, and procedures to manage copyright information and other intellectual property and associated rights in a network environment. This system will serve as a testbed for the evaluation of the concepts and issues of electronic copyright deposit, registration, and recordation of transfers of ownership and licensing transactions. This development effort is an interagency effort involving agencies from both the executive and legislative branches.

■ **Archival and Digitization Projects.** The United States National Archives and Record Administration (NARA) continues to evolve mechanisms for management of digital archives. NARA's Center for Electronic Records appraises, collects, preserves, and provides access to U.S. federal records in electronic format. The Center maintains electronic records created by the U.S. Congress, the courts, the Executive Office of the President, Presidential commissions, and nearly 100 bureaus, departments, and other components of executive branch agencies and their contractors.

The National Library of Medicine (NLM) is developing the capacity to acquire, store, and distribute large collections of digital images, including digital pages created as part of the System for Automated Interlibrary Loan (SAIL), diagnostic radiology images used by the Diagnostic X-ray Prototype Network (DXPnet) project, and the 2-D and 3-D anatomic images acquired as part of the Visible Human Project.

Other federal agencies actively exploring efforts to convert traditional-media material to electronic form to improve access and preservation include the Smithsonian Institution and the Library of Congress (American Memory project).

Non-Government Applications

R&D and pilot projects are being undertaken by many non-federal government organizations representing both commercial and non-commercial entities interested in participating in the NII. These efforts are vital both for the continued development of the infrastructure and for the establishment of roles and policy in the electronic environment.

Publishers. There are currently a number of experimental projects under way to use networks to deliver documents or provide access to images of print publications. These include services offered by Colorado Alliance of Research Libraries (CARL), Engineering Index (EI), University Microfilms International (UMI), and Faxon often in partnerships with secondary database access providers such as the Online Computer Library Center (OCLC), the Research Libraries Group (RLG), or Dialog.

EI, UMI, AT&T (InterNIC), Faxon, Elsevier, and Springer-Verlag are also undertaking projects to develop the infrastructure for digital publication and conversion, navigation and retrieval, and interoperability standards.

Several scientific journal publishers such as Elsevier and Springer-Verlag are conducting experiments with universities to make the contents of certain journals available electronically to the university either under site licenses or pay-per-view agreements. Third-party aggregators and relicensers such as UMI and Information Access Corporation are licensing full-text or journal-page images for specific areas directly to institutions. A number of publishers are making the text of their publications available for searching through database access providers such as Dialog or BRS on a transactional basis.

Journals published only in electronic form are well established and growing in number. Most are free; only a few are refereed and those constitute a minor force in the academic tenure process. The growing number of respected free electronic journals and newsletters include *Psycoloquy*, *Public Access Computer Systems Review*, and the *Library of Congress Cataloging Newsline*. Some subscription journals have begun to be published electronically. These include OCLC/AAAS (Online Computer Library Center/American Association for the Advancement of Science) Online Journal of Current Clinical Trials, which is peer-reviewed, and John Quarterman's Matrix News, published both electronically and in print. Copyright issues relating to electronic journals still need to be resolved.

In the sciences, distinguished print journals are now or soon will be published in digital as well as print form. *Mathematical Reviews* and the *Bulletin of the American Mathematical Society* are available in electronic and print form. Plans have been announced to publish digital forms of both the *Physical Review Letters* and the *Astrophysical Journal Letters*. The same is true of several popular magazines (i.e., *Mother Jones*, *Wired*).

Academic and Research. Academic and research institutions and professional associations have also pioneered digital library or infrastructure building projects, with spectacular success in forcing the expansion of the Internet and related electronic mail services, and are becoming increasingly influential in the areas of navigational software development and retrieval applications. All but one of the most common navigational tools on the Internet was developed at research or academic organizations (Gopher, Archie, WWW, and Mosaic; the original WAIS implementation was developed by commercial organizations). Academic institutions are also at the forefront of diverse and active electronic publishing ventures, facilitated both by the LISTSERV software, and increasingly by Gopher and WWW.[7] Gopher was developed at the University of Minnesota. WAIS was developed cooperatively by Thinking Machines Co., Apple Computer, Dow Jones & Co., and KPMG Peat Marwick. WWW was originally developed by CERN (the European Particle Physics Laboratory) and is currently being implemented along with Mosaic, an interface developed at the National Center for Supercomputing Applications (NCSA) facility at the University of Illinois at Champaign-Urbana. The Internet LISTSERV software was developed by Anastasios Kotsikonas at the University of Boston.

Other academia-private sector cooperative ventures are the University of Massachusetts (at Amherst) Inquery and Tipster projects, funded with NSF and other federal money, and developed in collaboration with several major commercial publishing partners. Another tool of interest that is being developed by public and private funds is the Knowbot Information Service (KIS). KIS is designed to act as a personal digital assistant to locate, evaluate, and retrieve

[7] Gopher is used extensively for Campus-Wide Information Systems and is widely implemented in academic and government communities. The hypertext-based WWW is being implemented along with Mosaic software for searching mixed-format data. WAIS is widely used for text indexing and searching on the Internet. The Internet LISTSERV software is used extensively for email forums.

information based on the user's requirements and other constraints (such as the willingness to pay for information). Elsewhere software vendors and database publishers are making important strides in the development of powerful retrieval engines (e.g., Oracle's ConTEXT).

Community. Community projects of interest include the Blacksburg, Virginia Electronic Village (BEV), the San Francisco Public Library Community Electronic Information Infrastructure (SFPL/CEII), and NYSERNet's Project GAIN (Global Access Information Network). Community-focused projects tend to produce a model where library services have an integral (but not necessarily a central) role in a large set of information delivery and communication tools and services. These projects are typically intended to promote interactivity among members of the communities.

The BEV project is a collaborative effort between the town of Blacksburg, Virginia Polytechnic Institute, and C&P Telephone to create a network of high-capacity data communications and services with the objective of linking members of the community with each other and with the Internet. Information available through BEV currently includes electronic mail and access to local and Internet resources. Potentially, all residents of Blacksburg will be able to connect to BEV from their homes.

The SFPL/CEII initiative, is another ambitious community project that is still in the planning phase. This project focuses on the use of worldwide resources to support the information needs of a specific community, in this case San Francisco.

The NYSERNet GAIN project extended Internet access and training to five rural New York State public libraries and one Indian national school.

The project clearly demonstrated that public librarians in a very rural setting with limited resources...could in fact get connected to the Internet, use a broad range of equipment and electronic services, develop new types of services to the community, and create a sense of excitement that came out of the library. Their sense of excitement and discovery translated into programs and applications that often put the public library at the foreground of technology application in the entire community [McClure et al, 40].

Standards

Standards-setting Groups. Several major groups are developing standards for the information technology, electronic information, and computer networking components of the NII. The groups are the International Organization for Standardization (ISO) and its U.S. counterpart, the American National Standards Institute (ANSI); the National Information Standards Organization (NISO), an ANSI-accredited standards developing body serving the publishing, library, and information services communities; the National Institute of Standards and Technology (NIST), which develops and coordinates standards for the federal government and leads U.S. standards development generally; ad-hoc standards groups, which usually focus on a single problem such as UNICODE or the Open Software Foundation (OSF); the Internet Engineering Task Force (IETF), an informal standards making group that generates Internet standards; and the Internet Society which is responsible for the Internet standards process. A newly formed group known as the Cross-Industry Working Team is striving to create a consensus view of the required standards.

Data Description. Standards are needed for the description of data. Tangible, traditional library materials are physically described, classified, and given a physical location code. In the past all these operations have been carried out by libraries. When retrieval is necessary, access is gained by looking up an item's classification number indicating where the physical item is located and where it may be retrieved. Currently, the extension to the USMARC (U.S. Machine Readable Cataloging) record for data description is a stable standard which can be used for electronic items.

In digital libraries both the access scheme and the retrieval needs have changed. To access an electronic item, additional information may be required, including information about the medium or system requirements (such as in the case of a computer program). A standard for this description must be implemented. ANSI/ISO and the IETF are currently working on such standards.

While a formal standard for information description is highly desirable, the cost, the slowness of the process, and the demands and politics of the international networking arena make this a difficult area. With the transition to electronic material, the need for such manual descriptive techniques may be supplanted by electronic methods for abstracting, indexing, or otherwise capturing the high-level descriptive information necessary for efficient access.

Computer-to-Computer Communications. One standard that is stable, and that has the potential to be of use initially, is the ANSI/NISO Z39.50 standard for system-to-system communications for retrieval. The ARPA CS-TR project is exploring new approaches for computer-to-computer communications that go beyond the existing Z39.50 standard.

Cryptography, Security, and Privacy. Cryptographic technology, essential to ensuring electronic information integrity, must exist before large information providers will participate in the network. Standards for cryptography will only be developed in a policy framework that does not impede their development. The issues of intellectual property and export controls on cryptographic technologies must be resolved before proposals in this area are internationally accepted and implemented.

Crude measures such as restriction by password and network address are common ways to provide security for access to restricted information today. Measures for providing privacy to information seekers need to be defined, implemented, and made widely available.

Other Standards. Other standards which must be agreed upon are ones for exchanging and interpreting networked materials formats, and for assuring security of operations and information. There are multiple standards for sound, while standards for images are in their infancy.

Some progress has been made in the area of transmitting documents in specific formats. For text, Standard Generalized Markup Language (SGML) is frequently proposed for use as a document content standard for non-structured text. Standards mentioned for exchanging structured data include ASN.1 (Abstract Syntax Notation One), which is used in library applications, and EDI (Electronic Data Interchange).

Several of the Internet navigation and retrieval tools discussed earlier have become *de facto* standards in a relatively brief period of time. These include Gopher, WAIS, and WWW.

Private industry also is actively developing tools that may provide meta-standards (standards for the conversion of diverse ad hoc standards to a common form), such as Adobe's Acrobat and Common Ground software for the presentation of formatted text and other data.

These examples (not exhaustive) are illustrative of an extremely volatile, complex, active, and sometimes competitive mix of parties involved in building the portions of the NII of concern to libraries.

PART III: Where Do We Want to Be?

NII Long-Term Goals and the Role of Libraries

The long term goal of the NII is a world of ubiquitous information.

The realization of this vision for libraries depends on the reliability and universal accessibility of the information infrastructure. Society must not only have the ability to support projects to gather and control electronic information but must also underwrite funding to assure basic access. The realization of this vision is dependent on technological advances and policy that will allow all of the interested entities to work together within a single network and policy framework, whether corporate, library, government, research, or entertainment.

Achieving this long-term goal requires that commercial providers of information, libraries, and user communities discuss, explore, and develop a new paradigm for their roles in the evolving electronic community. Copyright, funding, standards, and privacy and security issues must be addressed in both the short and long runs.

Short-Term Goals

Copyright. It is obvious that we are at the beginning of an enormous revolution in communications. The copyright law is at the center of this

revolution and will determine the course it takes. The bulk of electronic material will be copyrighted, as is the bulk of published material today. The issue of the protection of copyrighted material must be addressed (effective and administratively feasible licensing systems will be the key). For now, there is a standoff. Copyright owners (publishers, information providers, authors), librarians, and others with interests in this area must come together to model agreements covering on-premise online access, transmission to the public, downloading and reprinting, and feasible payment mechanisms.

Funding. Library budgets have not kept pace with the costs of materials. As the prices for serials, monographs, and other materials have soared, library budgets have declined.[8] If libraries are to participate in the NII, funding is required to support all aspects of their electronic evolution. Funding to continue current operations is basic. To become digital libraries, funding is required to purchase and install equipment, provide connectivity, digitize core materials, and educate both the staff and the user communities.

Standards. The provision for international standards for interoperability, data description and storage, navigation and retrieval, authentication of retrieved material, cryptography, privacy, security, and preservation are essential before information providers will offer their data over networks or users will accept the network as the central provider of their information needs.

PART IV: How Are We Going to Get There?

Today's libraries, facing the challenges of developing improved electronic capabilities and addressing standardization and privacy issues, can work toward making a reality of the long-term NII vision and strengthen libraries' roles as information purveyors by working incrementally on a number of fronts. The government has a leading role in supporting many of these efforts, among them new applications of copyright regulations and law to deal with the emerging digital world; privacy protection; research and development in digital libraries; support for demonstration projects; education, training, retraining for those who will staff digital libraries; and ensured access to government information. Some of these government activities are outlined below.

The Government's Role

Funding of Operations. Governments currently support libraries at the state, local, and federal levels. While the costs of acquiring materials and administering collections have continued to rise during the past 20 years, library budgets have shrunk. Funding, therefore, is vital if libraries are to develop comprehensive electronic capabilities while continuing to offer existing services. Funding is needed to ensure the existence of equipment, connectivity, and education at the local level. This is particularly true of K-12 schools and public libraries. Many school and public libraries currently lack network access and knowledge of how to use the technology once access is achieved. Funding is also needed for prototype projects to explore the roles and relationships of libraries to the commercial and scholarly communities.

Facilitation of Standards Development. The government can play a leadership role by working closely with standards-setting groups to define standards and to clarify and expedite the standards-setting process. The federal government, with its need for broad government-wide consensus on the use of de facto as well as formal or de jure standards, is in a key position to help establish consensus on key standards. The Government Information Locator Service (GILS) group has made progress in this area by identifying and promoting the use of interoperability standards where they exist. For the progress made by GILS to be extended and utilized, government dissemination of information efforts must be coordinated with standards-setting efforts.

Providing a Testbed: Federal Information. The tremendous information output of the federal government is an ideal testing ground for the development of information retrieval and delivery because of its vast quantity and broad utility and interest, and because it is nearly all in the public domain.

[8] See Mellon Foundation Study. For the 24 public and private universities libraries included in the study, library budgets and expenditures as a percent of educational and general expenditures had declined from a high in 1974 of 4.05 percent to a low in 1990 of 3.20 percent [Cummings, 192].

Providing a Test Group: Depository Library Program.[9] Since 1983, the Joint Committee on Printing, the Ad Hoc Committee on Depository Library Access to Federal Automated Data Bases, and GPO have initiated projects to assess the viability of depository distribution of federal publications or products in electronic form. An analysis of the projects concluded that, "The primary implication of the pilot projects is that input from depository libraries is essential from the ground level in future planning efforts if electronic products are to succeed in depository libraries" [Aldrich and Jobe as quoted in Hernon and McClure, 73]. This group of 1,400 libraries is an ideal subset of libraries for a variety of test projects.

Policy Setting: Copyright. Resolution of the complex but important copyright issues will stimulate the growth of the national information infrastructure, including digital libraries. Copyright law encourages both creativity and the open dissemination of the products of creativity. The benefits which accrue to authors under U.S. Copyright law have spurred the U.S. to become the largest creator and exporter of copyright material in the world. From an NII or digital library perspective, the major issue is how to encourage copyright owners to make electronic material widely available under terms and conditions that are not administratively burdensome or unduly expensive. Related significant challenges are to develop guidelines which set forth permitted uses of digital information under the "fair use" exemptions to the Copyright Code (Section 107) and appropriate downloading or reproduction of digital information under Section 108 by libraries and archives.

■ **Dissemination Issues.** Publishers and other information providers are currently addressing many of the issues involved in electronic dissemination of their products and new bases for compensation. Today the answer to the acquisition and use of most electronic materials is individual contracts with publishers or other copyright owners. However, it is impossible for any library to negotiate thousands of contracts, and publishers will not want to do this either. Unfortunately, the results of efforts to standardize contracts, e.g., the Coalition for Networked Information's READI project, have been discouraging. Therefore, the possibilities of an information broker, a clearinghouse, or a collective rights organization for permissions and payments become attractive. Any system must be flexible enough to allow copyright owners to control rates and other conditions of access. Model contracts or blanket or site licenses must be considered. Additionally, the critical issue of fair use in a digital environment must be addressed. The development of guidelines to set forth permitted uses under the fair use section of the copyright law would be extremely useful; such a task, however, is formidable.

■ **Current Material.** For libraries, the issues are different for retrospective and current materials. With government encouragement and support, publishers, information providers, and librarians should be able to work together to develop effective and efficient mechanisms to safeguard the rights of copyrighted digital materials. There are already projects under way that are addressing this problem. One of these projects is the Electronic Copyright Management System sponsored by the LOC Copyright Office and Information Technology Services, ARPA, and CNRI. The system will provide mechanisms for electronic copyright deposit, registration, and recordation of transfers of copyright ownership as well as licensing transactions of works owned in a network environment.

■ **Retrospective Material.** For older materials, different solutions may be necessary. Here, copyright owners are difficult to find, and, indeed, the copyright status of works may be difficult to determine. For a library to convert materials to machine-readable form and make such works available digitally requires permission to reproduce and distribute them. Creative solutions must be developed that do not disadvantage authors and copyright owners.

■ **Definition Issues.** There are other difficult issues that must be explored. Only copyrightable expression is protected. Ideas, methods, systems, facts and the like are not. Works

[9] The Depository Library Program (DLP) is a national resource network designed to ensure free public access to all government produced and published information. Depository libraries are located in each state and congressional district to assure wide distribution of these documents. This commitment to public access to government information can be traced back to 1857 when it was resolved that printed documents should be made available to the public through official sources. The Depository Library Act of 1962 established the network of Regional Libraries and increased the potential number of depository libraries.

with expired copyright terms are free for all to use. Copyright terms vary from country to country; the Internet is increasingly international, and the NII will have international linkages. A national plan must consider the international implications. A number of questions will arise in a networked and digital environment: (1) How is "a work" defined? (2) How is authorship defined? (3) What about subsequent contributions when the author's contribution is similar to what is considered an adaptation? (4) What constitutes public communication or performance? and (5) How should the rights of reproduction, distribution, public performance, public display, and the making of derivative works be adapted to digital technology and networking?

■ **Groups Addressing the Issues.** The Intellectual Property Working Group of the Information Policy Committee of the Information Infrastructure Task Force (IITF) is directly addressing these and other issues. Others working on these issues are: the Coalition for Networked Information; the Copyright Clearance Center; Ted Nelson in his Xanadu project; the Information Industries Association with its "Digital Library" issues paper written by Joseph Ebersole; Gary Griswold of InfoLogic Software, Inc., with his proposal for a copyright tracking mechanism; Peter S. Graham, Librarian at Rutgers; and Carnegie Mellon's Information Networking Institute project for an Internet Billing Server prototype. The Library of Congress through its Digital Library Coordinating Committee also is addressing this area.

Industry Regulation (Cable, TV, Telecommunications). Key industries are currently making and implementing plans to move into the world of electronic information. Among them are the cable companies, the seven regional Bell companies, and various entertainment companies. All have pieces of the electronic infrastructure—cabling, a user base, or digitized data—upon which to build major information-providing businesses. These companies are undertaking mergers and acquisitions to supplement their areas of strength for the information industry they see evolving. Deregulation without safeguards could lead to the formation of oligopolies with price structures that effectively preclude the use of major amounts of timely information by the average citizen.

The federal government has an imminent and critical role in determining that affordable access by the public is assured.

Education.[10] The federal government plays a key role in the nation's education infrastructure, and the priority, direction, and support it provides to educational institutions at national, regional, and local levels will be critical to the ability of these institutions to gain meaningful access to the NII.

Important opportunities exist for the development of network connectivity in schools, and for the promotion of distance learning and other extensions of educational opportunities across age, economic, and geographic barriers. Early steps in this direction could include a program of grants to extend at least primitive access to the NII to virtually every school, and to support a broad program of distance learning curriculum development and teacher and librarian, particularly those who staff public and K-12 libraries, training drawing on the resources of the NII.

Once consistent connectivity exists for educational institutions, the foundation will have been laid for sharing the resources of digital libraries with students and educators. This means that libraries will continue to fulfill their traditional role as adjuncts to education.

Opportunities in the Coming Year

The most important opportunities in 1994 for the application of the NII to libraries may be the confrontation of copyright issues and policies, and the need to monitor and respond appropriately to the shifts taking place in the telecommunications and cable industries. All legislation that is passed in support of NII and NII-library programs is obviously of major importance.

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[10] See study done by D'Elia et al (funded by the Department of Education). The survey consisted of a sample (1,001) of the general public who were asked to evaluate ten roles of the public library (the ten categories included libraries' roles in the community, education, recreation, and as information provider), using four response categories ranging from "not important" through "very important." The three roles ranked most important were educational support center for students of all ages (88 percent); a learning center for adult independent learners (85 percent); a discovery and learning center for preschool children (83 percent).

The Transition of Libraries to the NII

There is great divergence between current library services, technology, and funding on the one hand and the vision of the NII for digital libraries on the other. There will, of necessity, be a transition period in which libraries continue to acquire, organize, collect, and preserve traditional materials in specific geographic sites, and continue to receive funding in much the same ways that they do currently.

The NII envisions "universal access," yet the infrastructure is incomplete. Work to be done includes everything from the fiber optic cabling to installing modems at the local public library, to the creation of software to make the navigation of diverse systems on diverse platforms easy, and the creation of standards to make it all work. It is unlikely that acquisitions will become fully electronic on a large scale—meaning that an information item can be ordered and delivered electronically—until issues concerning the roles and rights of authors, publishers, libraries, and users are clarified. Some type of descriptive record, such as the descriptive and subject record currently created by catalogers, will continue to be required for efficient searching and retrieval until hardware and software can create the abstract data for accurate searching of massive text files; or until libraries' hardware and software platforms are so powerful that searching massive amounts of textual and image data no longer presents a constraint.

Other components which must be addressed during the transition in order to fulfill the vision of the NII is the conversion of existing non-digital data and the assurance of access to and preservation of data in digital form. Due to the amount of material to be considered for digitization (500+ years of printed material, 150 years of photographs, 100 years of movies) and the number of problems associated with conversion (the lack of image standards, selection and organization practices for digital materials, the expense of the process, the strategic problem of mutilating an item in order to digitize it easily, copyright issues), building an efficient model for the digitization of analog must be considered early in the transition. Similarly, material created and only existing in digital form is not being archived or preserved in an orderly fashion. The issues of collecting digital items with a view to long-term archiving and preservation, particularly those without broad market appeal, are of little interest to entities interested in immediate economic reward. Archiving and preserving for posterity are largely being ignored at this time. Methods to assure the preservation of material of value to succeeding generations must be created.

In times of transition, sufficient funding to continue current operations while converting to and adopting new operations is critical. The libraries that make up the U.S. library community are funded through diverse and uncoordinated sources. Public libraries depend on local budgets; research libraries depend on their respective institution for their funding; government agency libraries are part of the federal budget; repositories depend on endowments and donations for funding. In times of economic restraint, such as today, funds to educational institutions, of which libraries often are a part, are among the first to be cut.

If libraries are to continue to perform the services currently provided and, at the same time, adopt technology that will make their participation in the NII a possibility, then a national plan to coordinate and supplement both the required efforts and funding is essential.

After the Transition: Digital Libraries

The transition to an information age will continue to be evolutionary rather than revolutionary. The need for physical access will decrease and demand for network-based access to information will increase. The evolution will occur for a variety of reasons: increasing demand for timely information; increasing costs of traditional material; lower costs and faster and cheaper networks which make digital knowledge networks feasible. Not the least of the reasons for the evolution will be a preference for access to material that is easily searched and manipulated.

The national digital library will be geographically distributed. It will consist of a network of publishers, vendors, libraries, other organizations, and individuals, public, commercial, and private, any of which can offer an item or collections of items. Digital libraries will allow users access to knowledge worldwide. Similarly, digital libraries will make their own databases available to users

of the worldwide network. At the same time, it will provide programs and services that will build a sense of community and meet the needs for access to information and knowledge for that community [Dowlin]. Digital libraries collectively will strive to contain all past and future knowledge in electronic form. In the United States, public libraries will try to assure that digital information is made available to all either for free or at a reasonable cost. Policy makers will have to resolve the copyright licensing issues as well as the issue of fair use in the electronic world to the satisfaction of authors and publishers, and to the continuing benefit of the public.

The role of librarians could evolve from electronic archivist to knowledge navigator of the network of data which is the library. Librarians will continue to acquire, organize, preserve, and make available information, but they also will be required to function as managers of electronic information. This role may require librarians to participate in all aspects of the knowledge chain, from advising authors on outlets, to placing digital material under control, to organizing data for ease of access, to instructing and guiding users.

Issues and Questions to be Addressed

Copyright

The advanced information infrastructure presents three significant and qualitatively new challenges to protecting intellectual property. First, digitization offers an unprecedented, easy, and inexpensive method to produce an indefinite number of perfect copies. Second, information in disparate media can be converted into a single digital stream and can be easily manipulated to create a variety of new works. Third, digitized information can be instantaneously distributed to and downloaded by thousands of users of the network.

If the NII environment is to prosper as expected, then contributions to it must flow from all sources: commercial, private, public, and government. If the information provided by these sources is to be valuable, creativity must continue to be remunerated.

Since the issues of intellectual property rights are critical to further development of the NII, how should the federal government work together with representative members of the information community to provide leadership to clarify the existing intellectual property laws[11] as they relate to electronic information in the networked environment? Should this include a review of the appropriateness of the current public policy objective of the copyright law—the attempt to strike a balance between copyright rights holders and the public good? How should the federal government help create an intellectual property rights model for the network environment? How should such models contribute to future collections of material in digital form?

Any new models must continue to encourage creativity while addressing the public and research communities' continued and legitimate information needs. Authors, publishers, scholars, librarians, information technology and service providers, the Copyright Office, and the public all must be represented in any modeling and decision-making efforts. Consideration must be given to the impact that the recommendations of the Intellectual Property Working Group of the Information Policy Committee of the NII will have.

What kind of pilot projects are appropriate to explore issues, establish precedents, clarify roles, and identify standards, policies, and models for fair use and protection of rights in the digital environment? Such projects should include exploring prototypes that protect the rights of copyright owners while at the same time allowing use of material in research and public libraries (i.e., browsing, research by one or a small set of users for the advancement of knowledge).

The Electronic Copyright Management System pilot currently being developed by ARPA, CNRI, and LOC will provide an electronic means for handling the deposit, registration, and recording of copyright ownership as well as licensing transactions of works already owned. This project can begin the process of building future digital collections and serve as a model for non-

[11] Copyright in the United States is established by the Constitution and confirmed by statute. Its original purpose was to encourage intellectual productivity by securing intellectual property rights for authors while promoting fair public access to their output. Only expression is protected; the manner is which the expression is packaged is not.

participating publishers. Once it is operational the challenge will be how to expand it to include more partners.

Equity of Access and Education

The specter of information "have-nots" in the midst of the wealth of NII information must be averted. Access and education are two key ways to increase the probability that the number of the information "have-nots" will be reduced. What should the federal government's role in reducing the potential for information "have-nots" be and how can it achieve the vision of universal access? How should the federal government fund programs for public gateways and for the education of librarians in the new technology.

What institutions will act as gateways for those not having access or technical knowledge sufficient to make use of the NII? Isn't this the emerging role of libraries? What funding should be extended, refocused, initiated to stimulate connectivity for gateway institutions such as libraries?

What role will the federal government play in funding the education of the NII knowledge organizer-navigator? Isn't this the emerging role of librarians in the NII? Who will be trained to be the knowledge organizer and navigator of the NII databases?

Providing access and strengthening the technical position of libraries offers a strong possibility for providing equitable access. One means of doing this is to extend and re-focus the Library Services and Construction Act (LSCA) through FY 1998 to explicitly encourage libraries, particularly public and depository, to become public gateways to the National Information Infrastructure.

LSCA-funded gateways could begin to provide for universal access to the national digital library's information. Is it appropriate to substitute funding for the purchase of necessary computer and network hardware and software and training of staff by public and depository libraries for the current LSCA funding authority for public library construction?

The LSCA currently is set to expire at the end of FY 1994. The Administration's FY 1995 budget request proposes to continue at level funding the largest LSCA program for improvement of public library services. President Clinton's proposal in the State of the Union address to extend the NII to every school and library is partially addressed in the proposed budget by continued funding of the LSCA program for interlibrary cooperation. Although level funding is requested for this program, the "requested level would enable the States to expand their networking capabilities and library participation in development of the National Information Infrastructure."

What means are there to provide funds for librarians so that they are prepared for the technological challenges of advanced networks and search tools and also able to undertake digitization of unique resources in academic and research libraries?

Funding to provide broader access and to strengthen the technical position of public, depository, and academic libraries offers the possibility of providing equitable access for all. Education of the leaders in the library community could strengthen the technological knowledge of librarians so that they are able to employ the technology optimally and train others to do the same.

Digital Conversion

Much of the concern of the National Information Infrastructure has been with connectivity and access. There is an increasing need to focus on content, as reflected by the Committee on Applications and Technology (CAT) mandate. While discussions of digital initiatives are generally broad and imply the existence of digitized data through the conversion of existing holdings in major libraries, the issues surrounding the digitization of these holdings are frequently avoided. Who is going to do the digitizing? Should this be undertaken by a single institution or by multiple institutions? What institution(s) have the holdings and the expertise to initiate significant pilot projects in this area? What comprises a significant set of material worthy of the funding of such major projects? How should the federal government fund these initiatives? It is clear that market forces are unlikely to produce the resources required to initiate this effort on a meaningful scale. However, are there private entities

that could help supplement federally initiated digitization projects?

One set of materials that should be digitized[12] is held by the Library of Congress. This material consists of more than 200 collections that represent the American cultural heritage. These collections contain more than one million items: books, manuscripts, microfilm, photographs, recorded sound, music, and maps. The suggestion that the Library's Americana collections be considered for digitization is based on the collections' reflection of the nation's heritage, the broad public interest in the material, and their specific value to education. The digitization of these collections presents a less significant problem than many others would in that the materials are either no longer subject to copyright or permissions for re-publication have already been granted. It is also attractive for a project of this magnitude to be broached initially by a single institution. Such a project could serve to establish a model which could then be expanded to other libraries holding important Americana materials. The objective would be to create a networked set of distributed, network-accessible databases on the American experience for education within this decade.

In the long run, creation and implementation of appropriate intellectual property protection models will permit the future collection of material in digital form. This, however, will not address the rich heritage of material that exists now in libraries and which will never be accessible over the network unless digitized. It is essential that some of the legislation under consideration, as well as some of the budget proposals being drafted, address digitization.

Federal Investment in R&D

Which areas to be considered for research have the potential to contribute the most rapid development and orderly growth of digital libraries as part of the NII? What searching aids could be designed for the short term? for the long term? What basic architectural components of the digital library are in place? Which are missing? What issues must be resolved before the public will be willing to depend on the network in the same ways it trusts traditional libraries and the voice network? What are the models for preservation in the NII, both for material that only exists in digital form and material that exists in other forms that are endangered? Who will provide a testbed for digital repositories? What should be included in this testbed?

How should the federal government deploy its funding support to focus the necessary research efforts on the following areas:

- Schemes for classification and the building of lexicons and thesauruses are vital. Given the magnitude of data that will be searchable in the electronic environment, more efficient searching mechanisms must be built. Broader, more orderly, and more up-to-date classifications are one way to do this. Similarly, well-designed electronic lexicons and thesauruses can reduce the number of search query iterations and improve the precision of the response without excessive user intervention.

- The basic architecture to guide the implementation of library systems is needed. Many components are already in place: processing, storage, networking, authoring tools, and intellectual property law. Components missing from this architecture are: full technological interoperability; mechanisms to determine availability and ownership of items; a means to electronically receive permission for use.

- "Smarter" tools are needed. Currently, the amount of information retrieved from the network (directly and precisely related to the topic) is highly correlated with the expertise of the user searching the network.

- The issues of privacy and security must be resolved before the public will be willing to trust the network.

- Models for preservation, both for material that only exists in digital form and material that exists in other forms that are endangered, are currently lacking.

- Finally, testbeds for digital repositories must be established. Any testbed must provide: acceptance of digital items; authentication of the

[12] The Library's Americana holdings are much greater than the estimated 1 million items contained in these 200 collections. The Library's Americana holdings are estimated to be closer to 40,000,000. These 200 collections are those that have been identified as important to the culture of the United States and for which copyright protection either no longer exists because the materials are in the public domain or permission for use is a reasonable certainty.

item and its source; the ability to interface the item(s) with other systems as required (for example, copyright management); a means to authenticate and respond to requests to identify or provide access to stored items; the ability to provide a multimedia response; a means to impose conditions on the use of an item; and ongoing management of all stored items.

Coordination and Review of Standards

Better coordination of standards-setting groups should be initiated so that standards on internetworking, interoperability, and security are created and adopted in a more timely way. In a dynamic and quickly changing environment such as the Internet and the future NII, standards groups must consider streamlining the process for setting *de jure* standards and creating a process to adopt *de facto* standards when they are useful.

How can the federal government most effectively participate in the setting of appropriate standards for libraries?

Any national efforts to review standards-setting groups and methods should be undertaken with a clear sense that the network is already an international entity and that its international component is likely to grow as quickly (or quicker) than the national entity.

Conclusions

Libraries are central to the success of the NII. Librarians have already begun to explore the challenges presented by electronic materials and navigation tools. Enhanced skills, roles, and alliances in the electronic environment must be explored and developed before the vision of NII digital libraries becomes a reality. Libraries and librarians are anxious to assume their place in this electronic world, but basic issues must be addressed. These issues include copyright licensing schemes, collective rights administration and guidelines for fair use in an electronic environment, the availability of sufficient resources to ensure reliable connectivity and staff knowledge in network use, and databases of sufficient quality and quantity to be useful to those in need of reliable information. While the growth of the Internet has been impressive, the NII is a much more comprehensive, ambitious initiative which necessitates resolving significant issues and meeting critical objectives for Libraries as well as other application areas.

Finally, the network world is now international. Any national efforts, therefore, must consider the international context and implications.

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Government Service Delivery: Reengineering Through Information Technology

DRAFT FOR PUBLIC COMMENT

PART I: What Is the Application Arena?

Description of Government Service Delivery and Information Dissemination

President Clinton has spoken often about the "trust deficit"—the sad reality that the American people lack confidence that government will do the right thing. Improving customer service is the most direct way to attack this trust deficit. In the National Performance Review (NPR) report, Vice President Al Gore recommended an executive order to create a customer-driven government. The President signed this order on September 7, 1993. It sets the standard for government services to equal the best in business, and it requires federal agencies to survey their customers on what they want and whether they are satisfied. In announcing the NPR on March 3, 1993, the President said: "... We intend to redesign, to reinvent, to reinvigorate the entire national government..." These comments were motivated in part by the lack of public confidence in the federal government's ability to deliver services. Focusing on "Putting Customers First" as one of the four major themes in the NPR, Vice President Al Gore, in one of his many town hall meetings had this to say: "... we are going to make the federal government customer friendly. A lot of people don't realize that the federal government has customers. We have customers. The American people."

One of the NPR teams, Reengineering Through Information Technology (IT), examined ways to better serve customers through the use of IT. The findings and recommendations contained in the IT report form the basis for this Application Paper. The NPR IT Team confronted the fact that dealing with the Federal government is often complicated, slow, and confusing. Compounding the problem is that public access to government services is uncoordinated, cumbersome, and paper based. Further, if more than one agency is involved, an individual or business entity usually goes through two or more rounds of inquiries just to find a cognizant office. Contrast this maze with credit card companies who can resolve an issue at 1:00 AM, or an express delivery company which can find your package anywhere on earth—why can't the government do as well? Although a big part of the problem is due to the large amount of information that the government processes and files, it is equally true that where technology solutions do exist, the government is falling far behind the private sector in using technology to deliver services.

What is the Public Interest/Benefits in Promoting the Application?

Information technology has brought the convenience of revolutionary change to everyday life, from bank Automatic Teller Machines to global transfers of funds, from 800 telephone services to personal home computers, "e-mail," and the world-wide Internet computer telecommunications system. Whatever its problems, the information revolution is upon us. Many authors call such technology the most powerful tool for change in the modern era. American businesses, particularly the smarter ones, are taking notice.

The Clinton Administration wants to reengineer governmental processes using information technology to improve Americans' quality of life and reinvigorate the economy. The administration has identified technology as the "engine of economic growth." Further, public expectations for good service in a service based economy are at an all time high. Providing high quality government service to Americans is no exception.

Good service includes good access to information. Government information is a public asset. The government should make information available to the public on timely and equitable terms. It should foster the existing diversity of information sources, in which the private sector, along with State and local governments, libraries, and other entities are significant partners. These principles apply whatever the medium, printed or electronic, in which the information has been collected or stored.

The development of public networks such as the Internet and NREN (National Research and Education Network) will contribute significantly to this diversity. They will enable government information to be inexpensively disseminated to a broad range of users. In June, 1993, the Office of Mananagement and Budget (OMB) issued a revision to its Circular A-130 that sets forth these principles and provides specific management guidance to agencies regarding their implementation.

Evidence of the Benefits of an Electronic Government

Today, information technology can create the government of the future, the electronic government. Electronic government overcomes the barriers of time and distance to perform the business of government and give people public information and services when and where they want it. It can swiftly transfer funds, answer questions, collect and validate data and keep information flowing smoothly within and outside government.

In electronic government, high speed telecommunications links (information highways) will carry the data necessary to support government operations. These information highways will connect federal, state, and local governments, and help form a National Information Infrastructure (NII) made up of public and private transmission circuits and information services. The development of this infrastructure will enable the creation of "virtual agencies" which will give citizens access to integrated program information and services organized around service "themes" (e.g., unemployment assistance), rather than bureaucratic – and often – idiosyncratic – structures. In a virtual agency, several interconnected intergovernmental entities will be able to provide information and services in a seamless manner.

Examples of some of these services and the associated benefits are:

- *Citizen Services* – One-stop shopping for common government information and services, kiosks in shopping centers, electronic town hall meetings.
- *Healthcare Services* – Remote diagnostics and expert consultations, more efficient sharing of healthcare resources, improved access to medical records, realtime training on new medical procedures.
- *Law Enforcement and Criminal Justice* – Arraignments and parole board hearings via video technology, near real-time fingerprint identification via a national law enforcement public safety network.
- *Research and Education* – Distance learning, more efficient sharing of super computing and educational resources, improved access to large volume data libraries, and others such as tax law training.
- *Human Resources Management* – Job assessments and training via video technology at convenient locations, increased accessibility for individuals with disabilities, and flexible workplace.

PART II: Where Are We Now?

The NPR validated the lack of a cohesive approach to service delivery. The NPR report emphasized that citizens and government workers contend with an increasingly complicated array of federal agencies, organizations, processes and forms. The existing service delivery system is largely based on hierarchical design structures developed in the 1930s. The result is slow, inefficient service that may not satisfy actual

customer needs. The information needed for sound decision-making and high-quality customer service is not coordinated across government agencies, thus increasing cost and time to provide services. In short, today's government structures, processes, and business practices which were designed for a different era, cannot keep up with the existing types and volumes of customer demands. Information technology will be the key to providing more cost-effective and user-friendly government services. Industry examples illustrate how exploiting technology can provide superior customer service, significantly decrease costs, increase quality, and improve overall effectiveness and competitiveness.

For various reasons – some regulatory, some legislative, some cultural – the federal government lacks appropriate access to the most efficient, cost effective information technology products and services. The government has lacked not only strong leadership in this area, but also a coherent plan on how to most effectively tap information technology's potential for service to the public. When it comes to applications of information technology, the federal government is woefully behind the times, unable to use even the most basic technology to conduct its business in some cases. To correct this problem, the NPR IT Report focused on three areas where improvements must be made in order for the government to reap the full benefits available through the use of information technology. These include:

- Strengthening Leadership in Information Technology
- Creating an Electronic Government
- Establishing Support Mechanisms for Electronic Government

Leadership

The recently created Information Infrastructure Task Force (IITF) can provide leadership in integrating information technology into systems that support government's operation. This task force is responsible for articulating and implementing the President's vision for advanced telecommunications and computing technology. It is uniquely positioned to help develop the governmental aspects of America's information infrastructure. The IITF's Committee on Applications and Technology has established a Government Information Technology Services (GITS) Working Group which, in turn, will collaborate with state and local governments as well as the private sector.

The GITS Working Group is developing a strategic vision and an implementation plan for using government information resources across and within agencies, and developing steps to improve how government provides information and services to the public. In addition, the GITS Working Group is developing strategies to empower information technology management in federal agencies and setting priorities for sharing information among agencies.

Creating an Electronic Government

As the NPR IT Team recognized, information technology, with its ability to electronically store and rapidly access, sort, and transmit information, is the key to improving information dissemination and service delivery. When used to its full potential, information technology goes beyond the automation of paper processes – it allows agencies to rethink and redesign work processes to eliminate steps and make them more effective. The vision of "electronic government" extends the idea first seen in electronic banking. Just as ATMs, plastic access cards, and nationwide networks have made banking more convenient, electronic government will make communicating with government easier and faster. To inaugurate the concept of "electronic government," the NPR IT Team identified seven illustrative IT initiatives, which if implemented, will provide substantial return on investment through increases in productivity. These include:

Integrated Electronic Benefit Transfer – Electronic benefit transfer will use information technology present in the financial industry to deliver, nationwide, fast and efficient government assistance – including Food Stamps, Social Security benefits, and veterans benefits.

Integrated Electronic Access to Government Information and Services – Access to government is a right of Americans. Existing technology makes possible the integrated electronic access to government information and services. The use of a single nationwide 800 telephone number would simplify access to government agencies. Electronic government kiosks that use technology similar to that in ATMs can provide

"one-stop shopping" for both government information and services. Personal computers may also be used to access electronic bulletin board systems, databases, and agency directory services.

National Law Enforcement/Public Safety Network – A National Law Enforcement/Public Safety tactical network will improve coordination and communications among federal, state, and local law enforcement and public safety agencies, and will save money. It must focus on establishing standards for sharing information and implementing appropriate privacy and security measures.

Intergovernmental Tax Filing, Reporting, and Payments Processing – The Internal Revenue Service (IRS) already has on file all the tax information to calculate the taxes due for about 60 million taxpayers because financial institutions and employers are required to report this information. Yet IRS and state tax agencies still require taxpayers to compute what the IRS already knows. If IRS computed taxes and sent a statement, and if electronic filing were used for all others, IRS could forgo the mailing of 75 boxcars of forms to taxpayers – and certain classes could ultimately not need to file. For others, they will need to file only once. Enormous administrative savings would accrue to government and the burden on taxpayers would be reduced.

International Trade Data System – To help ensure the nation's competitiveness in global markets, the Treasury Department should create an all-inclusive database for disseminating international trade data, for use by the government and the trade community.

National Environmental Data Index – The National Oceanic and Atmospheric Administration should create a National Environmental Data Index to coordinate the development and use of environmental data gathered by various government agencies. Its goal – to give government, the private sector, academia, and citizens easy access to environmental information.

Governmentwide Electronic Mail – In the private sector, e-mail and messaging systems are becoming as common as the desktop computer. Government wide electronic mail is a natural progression from paper-based government to an electronic government. E-mail allows rapid communications among employees across agency boundaries. The administration should work to connect all federal employees by electronic mail.

Support Mechanisms

The NPR IT Team also recognized that in order for "electronic government" to become a reality, support mechanisms to address specific issues must be put in place. These include:

- *Establishing the Government Information Infrastructure* – On a broad scale, the National Information Infrastructure (NII) will revolutionize the way we work, learn, shop, and live, and provide Americans the information they need, when they need it, and where they need it – whether in the form of text, images, sound, or video. This capability will "enhance the productivity of work and lead to dramatic improvements in social services, education, and entertainment

- The public and private sectors both must help improve the nation's information infrastructure. The Government Information Infrastructure (GII) as a sub-set of the NII must adopt forward-looking policies that promote the development of new technologies in the delivery of government information and services.

- The infrastructure will allow the government to consolidate and modernize its data processing centers and standardize many of its basic administrative functions ranging from payroll to management information systems. The GITS Working Group is developing an implementation plan for consolidating data processing installations and reengineering common application systems.

- *Developing Systems and Mechanisms to Ensure Privacy and Security* – Success in implementing electronic government also depends on public confidence. Electronic government must protect the information it processes and insure individual privacy. It must also protect national security interests, permit legitimate law enforcement activities, enhance global competitiveness and productivity for American business and industry, and ensure civil liberties. The government must define uniform privacy practices and generally accepted principles for information security. It must adopt a digital signature standard, and it must promulgate encryption standards for sensitive information.

- *Improving Methods of IT Acquisition* – The government also must expedite and simplify how

it acquires information technology. The market for computer hardware and software involves products for which the shelf life can be as short as a few months. In this environment, the government needs to establish more aggressive, innovative purchasing methods.

■ *Provide Incentives for Innovation* – The administration recognizes that initiatives to bring electronic government to the public require strategic relationships between government and the private sector. These relationships must include necessary incentives for innovation. Agencies should be able to retain a portion of savings produced through information technology for reinvestment, and use multi-year funding for information technology projects. The government should promote performance-based contracting for information technology products, allow the private sector to increase its profits if it can find ways to make government run more efficiently and cost effectively. It should create an innovation fund to finance innovative information projects within agencies.

■ *Provide Training and Technical Assistance in IT to Federal Employees* – Federal, state, and local employees must get training and technical assistance in information technology. The government should create a program to train nontechnical senior executives and political appointees. Moreover, the Office of Personnel Management and GSA should establish information resources management (IRM) competencies for federal employees pursuing appointments to IRM management positions.

Current Actions

Information technology must not be applied haphazardly or sporadically. It also must not be used simply to automate existing practices. Instead, information technology must be used to exponentially improve business practices in the government of the 21st century.

FedWorld

One operating example of an integrated electronic access service exists today within the marketplace called FedWorld™, established by National Technical Information Service. FedWorld is an online information service which provides the general public with a user-friendly, central resource for government information.

FedWorld offers both dial-up and Internet access, thus serving the needs of those using the developing "information highway" as well as those operating with current dial-up technology.

Since FedWorld was established eighteen months ago, NTIS has received over 400,000 calls from nearly 75,000 registered users, who have downloaded files over 330,000 times from the system. It currently serves many in the policy community as one of the primary points of dissemination for White House information. For example, over a gigabyte-worth of copies of the President's Report to America and the Health Security Plan were downloaded from FedWorld within 48 hours of the President's address to Congress.

FedWorld also allows users to "gateway" through the system to over 130 other publicly available government information systems, effectively providing "one-stop shopping" for many types of government information. As a result of the gateway, many of these systems are accessible from the Internet for the first time. NTIS does not charge agencies for these services.

Moreover, the public is not charged to use basic FedWorld services. Instead, NTIS is recovering system development and maintenance costs through the sale of products online and through subscriptions to a small number of specific databases and files in the system. FedWorld also provides information dissemination services on behalf of other agencies, for which NTIS charges the agencies based on their costs. The incremental cost of adding another agency's information, even in a highly customized way, is substantially lower for the agency than it would be for the agency to create its own stand-alone system with comparable support and customer service.

FedWorld is currently handling about 3,000 calls each day, but is in the process of a series of hardware and telecommunications upgrades that will allow a peak of 6,000 to 10,000 calls a day.

The Administration's plan for expanding FedWorld's capacity are included in an overall one-time $18 million request for FY 1995 to support three initiatives developed by NTIS that are aimed at expediting the transition to full electronic dissemination of scientific, technical, and

other government information to all users. The request targets $6 million specifically for FedWorld to gain capacity and other enhancements that will permit FedWorld to serve the tens of thousands of daily callers that a fully operational system ought to be able to handle.

Government Information Technology Services

The Government Information Technology Services (GITS) Working Group is chartered to provide clear, strong leadership to integrate IT into government business processes to make government a customer-driven enterprise; define a vision and oversee implementation; encourage and facilitate cooperation; and serve as a catalyst for change. The GITS Working Group has begun work to develop an action plan that will address the following:

- Develop a strategic vision for using information resources within the federal government. This vision will define an overall strategy and master plan for information technology in the federal government and should include goals and objectives for improving government use of technology in mission performance – both across and within agencies – and measures for assessing service improvements to the public.
- Develop strategies to improve leadership and authority within federal agencies, and to continually benchmark against the best of private and public sector business practices.
- Set priorities for federal information resources management and assess the adequacy of resources to support and facilitate important goals.
- Develop an implementation plan for the IT recommendations in the NPR report and overseeing the execution of the plan across the government.
- Work with state and local governments and private sector advisers to promote cooperation and information sharing.
- Establish a continuous improvement process to design, develop, and implement technology-enabled governmentwide business initiatives – the electronic government.
- Identify additional opportunities and oversee follow-up on additional opportunities for sharing information resources across agencies to improve program performance.
- Use existing interagency groups such as the Federal iRM Policy Council (FIRMPoC) for assistance where applicable.

Working Group

In addition to the work being done by GITS, a sizable portion of the government services area being handled by the Information Policy Committee of the IITF in the areas of privacy, intellectual property rights, and information dissemination. One item in the information dissemination area – the government information locator service (GILS) illustrates the potential in this area.

On July 2, 1993, OMB revised Circular No. A-130, *Management of Federal Information Resources*, to strengthen polices for managing government information. Circular A-130 encourages agencies to utilize new technologies to make government information available to the public in a timely and equitable manner, via a diverse array of sources, both public and private. It states that availability of government information in diverse media, including electronic formats, permits the public greater flexibility in using the information, and that modern information technology presents opportunities to improve the management of government programs to provide better service to the public. It also notes that the development of public electronic information networks, such as the Internet, provides an additional way for agencies to increase the diversity of information sources available to the public.

In the spirit of the above polices, OMB has committed to promote the establishment of an agency-based GILS to help the public locate and access government information. Being a locator, GILS will be an information resource that identifies other information resources, describes the information available in those resources, and provides assistance in how to obtain the information. A key concept of GILS is that it uses network technology to arrange information to support many different views.

GILS will be a collective set of agency-based locators that is decentralized in order that ongoing maintenance responsibilities stay as close as possible to those who understand and care for the information. Each agency is responsible for

assuring that its GILS are continuously accessible to GILS direct users on the network, whether through agency computer resources or through other arrangements. Among the agency GILS are those designated as part of the GILS Core. The GILS Core is comprised of high-level descriptions of agency holdings in a specific format and maintained by the various agencies. These agency locators can be aggregated by direct users of GILS to provide a view of all Federal Government holdings, and they can be supplemented by non-GILS information sources of all kinds, or by non-Federal locators that are interoperable with the GILS Core.

Many people will use GILS by accessing resources directly on networks, but many others will use GILS through intermediate services. A researcher interested in government operations may access GILS directly over the Internet and explore issues from a variety of perspectives. Network service providers may offer GILS access to users as an option to their bulletin board services. An educator interested in education materials may access GILS once a month over a dial-up connection to the Internet. An information service may access GILS hourly and construct a value-added directory for sale to users with specific needs. When accessed directly as it exists on the network, GILS will provide maximum flexibility to create specific views of the full complement of available information. It should be noted that GILS will include some redundancy and will present information from a variety of perspectives. Casual users and those lacking network access facilities will be serviced typically through products created by agency or non-government intermediaries such as public libraries and private sector providers.

Participants in GILS will use formal standards processes to promote interoperability of search and retrieval mechanisms, network communications, user authentication, and server descriptions, among other essential components. Although near-term implementations of GILS may utilize the Internet and TCP/IP communication protocol for practical reasons, the GILS core will be based on the international Open Systems Interconnection (OSI) model and is designed to be compatible with other network technologies. GILS will take advantage of the network technology known as client-server architecture, which allows information to be distributed among multiple independent information sources. Applications can then be constructed to allow a user to question many sources concurrently and have the answers automatically combined. Because GILS will adopt existing information search and retrieval standards, direct users of GILS will gain access to a wide range of additional Federal sources. Other major Federal government information systems, such as the proposed Government Printing Office Access System, the NTIS FedWorld systems, the National Geospatial Data System, and the Global Change Data and Information System, can also be made readily accessible to GILS users. In fact, the Department of Commerce already has a prototype Commerce Information Locator System (CILS), in operation and available to the public, on NTIS' FedWorld.

PART III: Where Do We Want to Be?

Since formation, the GITS Working Group has adopted the vision of creating a Government that "**uses Information Technology to interact with and to serve its customers on their terms.**" To achieve this vision, the GITS Working Group will strive for the following goals:

- Develop a national vision which includes an institutionalized process that ranks IT priorities for the Administration, provides support and funding to achieve them, and coordinates partnerships with industry and state and local governments.

- Provide our customers with a modernized, electronic government to give them responsive and efficient access to information and services.

- Develop and implement information technologies, policies, procedures, and standards that empower leadership and support and enable customer-driven government, rather than constrain it.

Critical Success Factors

To achieve the vision and goals, the GITS Working Group will promote total customer satisfaction and make the U.S. Government a model and leader in the use of information technology in service delivery. Success can be measured based on performance criteria established for the following areas:

Customer Satisfaction

- Is the product the "right" product?
- Is the service level adequate?
- Is service delivery timely, accurate, accessible, affordable, ubiquitous, discreet, reliable, and easy to use?

Productivity/Efficiency

- Are there any cost reductions and/or improvements in the level of service?
- Has customer demand for IT services to solve business problems increased?
- Has the government eliminated unnecessary paper-based services?

Leadership

- Has the government become a model and leader in the use of information technology?
- Is IT being recognized as a strategic resource in agency plans?
- Has electronic access to information and services become more available?

Infrastructure

- Has easy and effective government-wide electronic mail communication been achieved?
- Are federal/state/local government services interoperable?
- Is service delivery integrated?

Partnership

- Is government/industry partnership working?
- Is federal/state/local government partnership working?

Continuous Improvement Program

The continuous improvement program is a "shared vision" of the GITS Working Group to provide a cross-agency environment for "open" communications and feedback within the government enterprise. Feedback coupled with a road map to the future being developed by the GITS Working Group will ensure a customer and stakeholder focus on an interactive basis. Customer suggestions will be evaluated and acted upon. Performance goals will be established and met. The GITS Working Group is focusing on system thinking, guiding principles, critical success factors and teamwork to form a cohesive way of approaching intergovernmental systems and services.

Critical success factors that measure the "to be" state require continuous monitoring with obstacles quickly handled. Stakeholder involvement in the overall improvement process is also required. Performance based contracting will reward contractors for continuous improvement in technology furnished to the government under contract. Agencies will be rewarded for identifying and implementing innovative customer-driven services in concert with the GITS Working Group strategic vision.

PART IV: How Are We Going to Get There?

To facilitate discussion in this area, this paper ends with three questions for the reader to consider in the development and deployment of the NII.

- **How can the government fund innovative IT projects?** Resource constraints, incremental budgeting practices, and a lack of incentives often discourage federal managers from investing in innovative information technology applications that might yield long-term benefits and that cut across program and agency boundaries. How could the government provide a source of financing for projects that might not otherwise receive agency funding due to the experimental nature of the technology, long payback periods, benefits that accrue to a number of agencies, or funding needs that exceed the normal one-year funding cycle?

- **What steps should the government take to issue a final digital signature standard?** A digital signature standard is considered a prerequisite for an electronic government. Initiatives such as electronic filing of tax returns depend on such a standard that can provide assurance of the integrity and authenticity of messages. Other applications such as financial transactions between governments, business and the public, equally depend on the establishment of such a standard. Patent problems and the cryptography debate have thus far stalled this initiative. One element that can be addressed independently of these concerns is the establishment of a "public key infrastructure" to support digital signatures. What are the appropriate next steps to making that infrastructure a reality?

- **How should the government use its buying power to promote investment in the national and local information infrastructure?**

The federal government is a major purchaser of IT, spending over $25 billion on commercial IT goods and services. As a major buyer, it can sometimes influence the market place and thus the direction of the NII.

For example, the vision of electronic government requires high levels of interoperation and integration among diverse networks. Although integrated voice and data services,can be provided through a technology called Integrated Services Digital Network (ISDN), interoperable ISDN service between networks remains elusive. The root of the problem is the lack of a common standard and reluctance in the private sector to invest in building the infrastructure to support ubiquitous ISDN service. The government has had limited success, through its FTS2000 network, in influencing the adoption of common standards and the building of this infrastructure. The FTS2000 contract put in place the first, national, multi-network intercity ISDN service. However, the infrastructure of the local carriers does not support extending this service beyond major metropolitan areas. This infrastructure deficiency severely limits the utility of ISDN service for government applications such as telecommuting and training. On a broader scale, the inability of the local carriers to support ISDN service to communities located at the outer edge of metropolitan areas and rural areas deprives the citizens a vital communications tool for accessing government services of the future. This example illustrates both the potential and the limitations of the using the government's buying power to influence markets. More strategic attention may be needed in using this tool to leverage investment in the NII.

Electronic Access to These Papers

In addition to receiving printed copies of "Putting the Information Infrastructure to Work: A Report of the Information Infrastructure Task Force's Committee on Applications and Technology" from NTIS or GPO, the document is also available electronically from the following sources:

1). The Information Infrastructure Task Force (IITF) Gopher Server: gopher, telnet (login = gopher), or anonymous ftp to iitf.doc.gov. The document is located within the Speeches/ Testimony/Documents category, documents/papers subcategory. Access is also available over the World-Wide Web (WWW).

2). The IITF Bulletin Board: Dial by modem to 202-501-1920. Modem communication parameters should be set at no parity, 8 data bits, and one stop (N, 8, 1). Modem speeds up to 14,400 baud are supported.

3). FedWorld: Telnet to fedworld.doc.gov or dialing by modem to 703-321-8020.

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